

DOCUMENT RESUME

ED 222 184

IR 010 417

AUTHOR Genensky, S. M.; And Others
 TITLE A Second-Generation Interactive Classroom Television System for the Partially Sighted.
 INSTITUTION Rand Corp., Santa Monica, Calif.
 SPONS AGENCY Office of Education (DHEW), Washington, D.C.
 REPORT NO R-2138-HEW
 PUB DATE Jun 77
 CONTRACT 300-75-0123
 NOTE 77p.; Photographs may not reproduce.
 EDRS PRICE MF01/PC04 Plus Postage.
 DESCRIPTORS *Audiovisual Aids; *Electronic Equipment; Elementary Education; *Input Output Devices; Instructional Materials; *Partial Vision; *Production Techniques; Reading Instruction; Video Equipment; Videotape Recordings
 IDENTIFIERS *Two Way Television

ABSTRACT

The interactive classroom television system (ICTS) that is described permits partially sighted students and their teachers to be in continuous, two-way visual communication. It was implemented in Rowland Heights, California, as part of the second phase of a project aimed at evaluating how the ICTS helps in teaching basic skills to partially sighted elementary school children in classroom settings. The first of two sections describes the function and operation of the system, which comprises eight stations, a master control unit, a room-viewing camera and control unit, a videotape recorder, and color TV monitor/receiver. Section 2 considers the design and electronic implementation of the ICTS, with emphasis on how the electronics are arranged and operate. Included are the overall organization of the system, the input/output board, the video and audio switching systems, synchronization, keyboard logic, and maintenance information. Appendix A gives detailed instructions for using the unit, and step-by-step instructions for coping with system failures are listed in appendix C. Three references are listed. (Author/LMM)

 * Reproductions supplied by EDRS are the best that can be made *
 * from the original document. *

ED222184

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)

✦ This document has been reproduced as
received from the person or organization
originating it.

Minor changes have been made to improve
reproduction quality.

- Points of view or opinions stated in this docu-
ment do not necessarily represent official NIE
position or policy.

A SECOND-GENERATION INTERACTIVE CLASSROOM TELEVISION SYSTEM FOR THE PARTIALLY SIGHTED

PREPARED FOR THE DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

S. M. GENENSKY, H. E. PETERSEN,
R. W. CLEWETT, R. I. YOSHIMURA

R-2138-HEW
JUNE 1977

Rand
SANTA MONICA, CA 90406

"PERMISSION TO REPRODUCE THIS
MATERIAL HAS BEEN GRANTED BY

Rand Corp.

TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC)."

IR010417

PREFACE

In November 1973, The Rand Corporation designed and built an interactive classroom television system (ICTS) that permits partially sighted students and their teachers to be in continuous two-way visual communication. The ICTS was installed in the Santa Monica Unified School District's Madison Elementary School. In February 1975, Rand began a study, under Contract 300-75-0123, with the Office of Education of the Department of Health, Education, and Welfare, aimed at evaluating how ICTSs help in teaching basic skills to partially sighted elementary school children in classroom settings. The contract called for designing and fabricating a second ICTS to be used in the evaluation.

This report describes the second ICTS, which was installed in the Rowland Unified School District's Killian Elementary School in Rowland Heights, California, in November 1975, and points out what improvements have been made to take advantage of the system's enormous capability.

Readers who are interested, in a broad sense, in learning what an ICTS is and how it operates may wish to confine their reading to Sec. I, "The Second-Generation ICTS," and readers seeking details of the logic used in the ICTS electronics should turn to Sec. II, "Design and Implementation Considerations."

SUMMARY

This report describes the various parts of the new ICTS and how they interact with one another. As presented in Sec. I, the system consists primarily of eight stations, a master control unit, a room-viewing camera, a room-viewing camera control unit, a videotape recorder, and a color TV monitor/receiver. The nerve center of the ICTS is the master control unit, which controls the source of the image presented on each of the system's TV monitors. The illustrated discussion demonstrates the power and versatility of this unit in presenting video and audio information to individual students or to groups of students. Detailed instructions on how to use the unit are given in App. A.

Section II considers the design and electronic implementation of the new ICTS, in particular how the electronics are arranged and operate. This includes the system's overall organization, the input/output board, the video and audio switching systems, synchronization, keyboard logic, and maintenance information. Step-by-step instructions on how a teacher can cope with system failures are listed in App. C.

ACKNOWLEDGMENTS

The authors deeply appreciate the work of Janice Banks, John Cull, Arthur Lucero, Steven Strand, and Donn Williams, who purchased, built, wired, or assembled the various parts of our second-generation ICTS. Their dedication was based not only on a desire to produce a high-quality, dependable system, but also on an interest in improving the lot of the partially sighted children who would use it. We especially thank Steven Strand, who volunteered his weekends and evenings, as well as his regular working hours, to constructing the ICTS and to maintaining it.

We thank the following members of the staff of the Rowland Unified School District: Dr. Stanley G. Oswalt, Superintendent; Dr. Clinton E. Boutwell, Assistant Superintendent, Educational Production Division; William D. Hatcher, Director of Special Education; Tully R. Valmassoi, Principal, Killian Elementary School; LaVerna Fredregill, Program Specialist, Visually Handicapped Program; Sandra L. Bridges, Special Education Psychologist; Levonne Kelly and Rikk Morris, teachers of the visually handicapped; and Kathleen Lane, Della Sewell, and Sue Stone, teaching assistants. The interest of these people in the visually impaired sets an example for every school district in the country, and their enthusiasm and support have made our ICTS installation at the Killian Elementary School a splendid success. We especially thank Levonne Kelly and Rikk Morris, who have turned a room full of partially sighted children, sophisticated equipment, teaching aides, and volunteers into a cheerful and smoothly functioning learning environment.

We also express our appreciation to the following members of the staff of the Santa Monica Unified School District, who welcomed our first ICTS into their school system in November 1973, and who, since that date, have done their best to ensure that partially sighted elementary school children benefit from the system: Dr. George L. Caldwell, Superintendent; Anthony Baretta, Assistant Superintendent, Education; Dr. Robert J. Stillwell, Supervisor, Special Education Services; Dr. Frank D. Taylor, Supervisor, Special Education Program Development; Arthur C. Bystrom, Principal, Madison Elementary School; Dr. O. Arthur Rosenthal, Psychologist; Jadeane B. von der Lieth, teacher of the visually handicapped; and Pam Harris and Judy Wolf, teaching assistants. Like their counterparts in the Rowland Unified School District, these people have demonstrated a dedication to their partially sighted elementary students that should be the envy of school districts everywhere. We especially thank Mrs. von der Lieth, not only for the superb way she conducts her class, but also for the suggestions and recommendations she made concerning system design and for her generosity in sharing her experiences with the first ICTS with those who were to use the second-generation ICTS.

We gratefully acknowledge the careful review of a draft of this report by our colleagues Drs. Thomas H. Bikson, Gabriel F. Groner, and Paul F. Morrison. Their comments, suggestions, and corrections have significantly improved the product. Any remaining shortcomings are attributable solely to the authors. We also deeply appreciate the careful reading and editing of the report by Eleanor T. Gernert, and the high-quality photographs taken by James A. Beavers and Jane Colbert Cobb.

Finally we thank our secretary Margaret Wray, who so patiently and accurately typed the various drafts of this report.

CONTENTS

PREFACE.....	iii
SUMMARY	v
ACKNOWLEDGMENTS	vii
FIGURES	xi
Section	
I. THE SECOND-GENERATION ICTS.....	1
The New ICTS	1
The Master Control Unit	5
The Control Console of the New Master Control Unit	9
Master Control Unit Audio Capabilities	16
The Room-Viewing Camera	17
The Room Monitor/Receiver.....	17
The Videotape Recorder	18
II. DESIGN AND IMPLEMENTATION CONSIDERATIONS.....	23
Overall Organization	23
The Input/Output Board	25
The Station Board for Video Switching	25
The Audio Switching System	30
System Synchronization	33
Keyboard Logic	33
Maintenance Considerations	34
REFERENCES	35
Appendix	
A. MASTER CONTROL UNIT FOR THE NEW ICTS.....	37
Functional Capabilities	37
Special Effect and Display Control	38
The ROOM MNTR Button.....	43
The RECORD Button.....	44
The ROOM MNTR and REC MNTR Buttons.....	46
Some Remarks on Audio	46
The TALK ALL Button.....	47
The Mode Buttons	47
Initial State of the NMCU	57
Monitoring the Display Status of the ICTS	57
B. COPY OF J. L. SHEPHERD LETTER REPORTING ON X-RAY MEASUREMENTS.....	63
C. MAINTENANCE INFORMATION FROM THE <i>SELF-HELP</i> MANUAL FOR THE NEW ICTS.....	65
Local Self Mode.....	65
Some Possible Failures	66

FIGURES

1. An ICTS student station	3
2. The teacher's station	4
3. A station monitor displaying the superposition of the negative image of a bird on the positive image of the word "bird"	6
4. A station monitor displaying the superposition of the positive image of a bird on the negative image of the word "bird"	6
5. A station monitor displaying a horizontally split image; the upper image is the positive image of a bird and the lower image is the negative image of someone writing the word "bird"	7
6. A station monitor displaying a horizontally split image; the upper image is of a bird and the lower image is of someone writing the word "bird"; both images are positive	7
7. A station monitor displaying a superimposed image of a teacher and student on that of a lowercase and uppercase "O"	8
8. A teacher and a teaching aide working with a student at his ICTS station	10
9. A student learning to play a harmonica at his ICTS station	11
10. A sketch of a control console for an eight-station ICTS that was considered but abandoned because of its complexity	13
11. The control console of the eight-station ICTS	14
12. The room-viewing camera	18
13. The eight-station ICTS at Killian Elementary School, Rowland Heights, California	19
14. The four-station ICTS at Madison Elementary School, Santa Monica, California	20
15. Students gathered around the room monitor/receiver	21
16. Printed circuit board used for video switching in the ICTS	24
17. Logic and video paths within a station board	27
18. Circuit used for audio switching	32
A.1. Schematic of the new master control unit (NMCU) control console	37
A.2. NMCU control console indicating that station 3's monitor is displaying a horizontally split image; the top half is from the teacher's camera and the bottom half is from the room-viewing camera	39
A.3. NMCU control console indicating that station 5's monitor is displaying a horizontally split image; the top half is from the room-viewing camera and the bottom half is from station 5's camera	40
A.4. NMCU control console indicating that station 4's monitor is displaying a full-screen image of what station 7's camera is viewing	40
A.5. NMCU control console indicating that station 2's monitor is	

	displaying a full-screen image of what the camera at this station is viewing	41
A.6.	NMCU control console indicating that station 3's monitor is displaying a full-screen superposition of the output from the room-viewing camera on that from station 3's camera	42
A.7.	NMCU control console indicating that station 5's monitor is displaying a full-screen superposition of the output from the camera at this station on itself	43
A.8a.	NMCU control console indicating that station 6's monitor is displaying a horizontally split image; the top half is from station 1's camera and the bottom half is from the teacher's camera	48
A.8b.	NMCU control console indicating that the ICTS is in the All-All mode and that the choice of image composition has yet to be made	49
A.8c.	NMCU control console indicating that every station monitor is displaying a full-screen image of the output from the room-viewing camera superimposed on that of the teacher's camera	49
A.9a.	NMCU control console indicating that the ICTS is in the Self-Self mode, but that the choice of special effect has not as yet been made	51
A.9b.	NMCU control console indicating that station 3's monitor is displaying a full-screen image of the output from the camera at this station	52
A.9c.	NMCU control console indicating that station 2's monitor is displaying a full-screen image of the output from this station's camera	52
A.9d.	NMCU control console indicating that station 7's monitor is displaying a full-screen image of the output from this station's camera superimposed on itself	53
A.10a.	NMCU control console indicating that the ICTS is in the All-Self mode, but that choices have yet to be made regarding the special effect and the image to be displayed on all station monitors	53
A.10b.	NMCU control console indicating that station 4's monitor is displaying a split screen image; the upper half is from the room-viewing camera and the lower half is from station 4's camera	54
A.10c.	NMCU control console indicating that station 3's monitor is displaying a horizontally split image; the upper half is from the room-viewing camera and the lower half is from station 3's camera	54
A.10d.	NMCU control console indicating that station 6's monitor is displaying an image of the output from the room-viewing camera superimposed on that from station 6's camera	55
A.11a.	NMCU control console indicating that station 1's monitor is displaying the output from the room-viewing camera	58
A.11b.	NMCU control console indicating that station 2's monitor is displaying a full-screen image of the output from this station's camera superimposed on the output from the teacher's camera ...	58

A.11c.	NMCU control console indicating that station 3's monitor is displaying a full-screen image of the output from this station's camera	59
A.11d.	NMCU control console indicating that station 4's monitor is displaying a full-screen image of the output from this station's camera superimposed on the output from the teacher's camera ...	59
A.11e.	NMCU control console indicating that station 5's monitor is displaying a full-screen image of the output from the videotape recorder	60
A.11f.	NMCU control console indicating that station 6's monitor is displaying a full-screen image of the output from this station's camera and that this image is being replicated on the room monitor/receiver	60
A.11g.	NMCU control console indicating that station 7's monitor is displaying a horizontally split image; the upper half is the output from station 5's camera and the lower half is the output from station 3's camera	61
A.11h.	NMCU control console indicating that the teacher's monitor is displaying a full-screen image of the output from station 3's camera	61

I. THE SECOND-GENERATION ICTS

This report describes a second-generation multicamera-multimonitor interactive classroom television system, which will be referred to as an interactive classroom TV system, an ICTS, or as the system. The ICTS was built with funds provided by a contract between the Department of Health, Education, and Welfare's Office of Education and Rand. It is currently being used by partially sighted children and their teachers in a classroom for the visually impaired in the Killian Elementary School in Rowland Heights (Los Angeles County), California. Evaluation of the Killian site is part of a program aimed at determining the effect of using such systems on the school experience of partially sighted elementary school children in operating settings. Included in this program is the first-generation ICTS, located in a classroom for visually impaired children in the Madison Elementary School in Santa Monica, California.¹

An ICTS permits partially sighted children to be in continuous visual communication with their teacher(s). It permits them to see what their teacher writes on a chalkboard while he is writing and explaining what he is doing. No longer is it necessary for these children to ascertain what the teacher has written on the board *after* he has completed writing and explaining what he has written.² The flexibility and versatility of an ICTS, in creating a visual and auditory milieu within which a partially sighted child can experience many of the perceptual interactions of fully sighted children, will become apparent as this report proceeds.

In what follows, a person will be considered to be partially sighted if the visual acuity in his better eye, even with the help of ordinary corrective lenses, does not exceed 20/70 but is sufficient to permit him to read and write as the literate sighted do or to recognize familiar objects as the illiterate sighted do, with or without the help of an optical or electro-optical aid.³ At least 1.66 million Americans meet the criteria of this definition, and about 310,000 make up 70 percent of this nation's 443,000 legally blind. These data support the assertion that the vast majority of the legally blind are *not* blind, but rather are partially sighted.

THE NEW ICTS

The new ICTS consists primarily of eight stations, a master control unit, a room-viewing camera, a room-viewing camera control unit, a videotape recorder, and a color TV monitor/receiver.

¹ The first-generation ICTS was built with funds provided by a grant from the Department of Health, Education, and Welfare's Rehabilitation Services Administration; the system is described in Ref. 1.

² It is not uncommon for a partially sighted student, in a classroom for fully sighted students, to have to wait until after class to learn what has been written on the chalkboard. Also, he may not be able to see everything on the board even if he stands very close to it. Further, there is the ever present possibility that some or all of the board will have been erased and/or replaced with new material.

³ A person whose visual acuity cannot be corrected to better than 20/70 in his better eye, even with ordinary corrective lenses, in general would not be able to read ordinary newspaper column type with or without such lenses.

Each station consists of the following components: a 17-in. Shibaden VM 172 TV monitor; a down-pointing Shibaden HV 40 CSR TV camera equipped with a 5 to 1 Visualtek VL6 zoom lens; an Art Beam Lite 75 illuminator; and a 16 by 14 in. X-Y Platform⁴ equipped with adjustable margin stops in the x- or line-traversing direction and a variable friction control in the y- or line-to-line direction. Each station camera is equipped with a switch that governs whether the image originating from the camera is positive or negative, that is, black on white or white on black. The contrast and brightness of the image on each monitor, as well as the vertical and horizontal hold, are controlled at the monitor by conveniently located knobs near the bottom of its front face. Seven of the stations are for use by students and the eighth is used primarily by the teachers. The eighth station could also be used by students whose vision is sufficient to permit them to view that station's monitor, which is located on top of the master control unit rather than on the table that supports the rest of the equipment associated with the teacher's station.

At each of the seven student stations, the TV monitor rests on its own stand, which is designed to permit the X-Y Platform, on which lies the printed or handwritten material, to pass below the monitor. This feature makes it possible, if desired, to bring the TV monitor closer to the TV camera than would otherwise be possible and still accommodate the rather large books used by young school children. The TV camera and its lens system are attached to a stand, which also supports the illuminator and the X-Y Platform. This stand is designed to permit the TV camera to be moved easily up or down. The station's power switch is on the front face of a boxlike structure at the rear and to the right of the camera stand's vertical support. The station's power line cord plugs into the rear of this box. Such an arrangement keeps the power line receptacles safely out of the reach of inquisitive little hands. To the left of the camera stand's vertical support, there is another box that houses the station's speaker, volume control knob, and receptacles for the station's microphone and earphone jacks. The receptacle for the cable that carries signals from the station to the master control unit and vice versa is at the rear of this box.

The monitors used at each station of the second ICTS, like those used with the original system, were tested by J. L. Shepherd and Associates of Glendale, California, to determine whether they presented any X-ray hazard to a person viewing them for long periods of time with his eyes in very close proximity to the face plates. As we expected, Shepherd found that, as in the case of the monitors used in the first ICTS, those used in the ICTS described in this report present no X-ray hazard whatsoever to persons using them even under the severe conditions specified above. A copy of Shepherd's report to Rand dated December 17, 1975, is reproduced in App. B.

Figure 1 shows an overall view of a student station of the new ICTS. This station is set up for use by a right-handed person. Notice that for a right-handed person (1) the illuminator is attached to the left of the camera stand's vertical support and its beam is directed down and to the right, and (2) the station's monitor is located to the left of the camera stand. Also observe the position of the three legs

⁴ References 2 and 3 contain detailed information about X-Y Platforms. The X-Y Platforms used in our ICTSs are similar to the one described in Ref. 2.

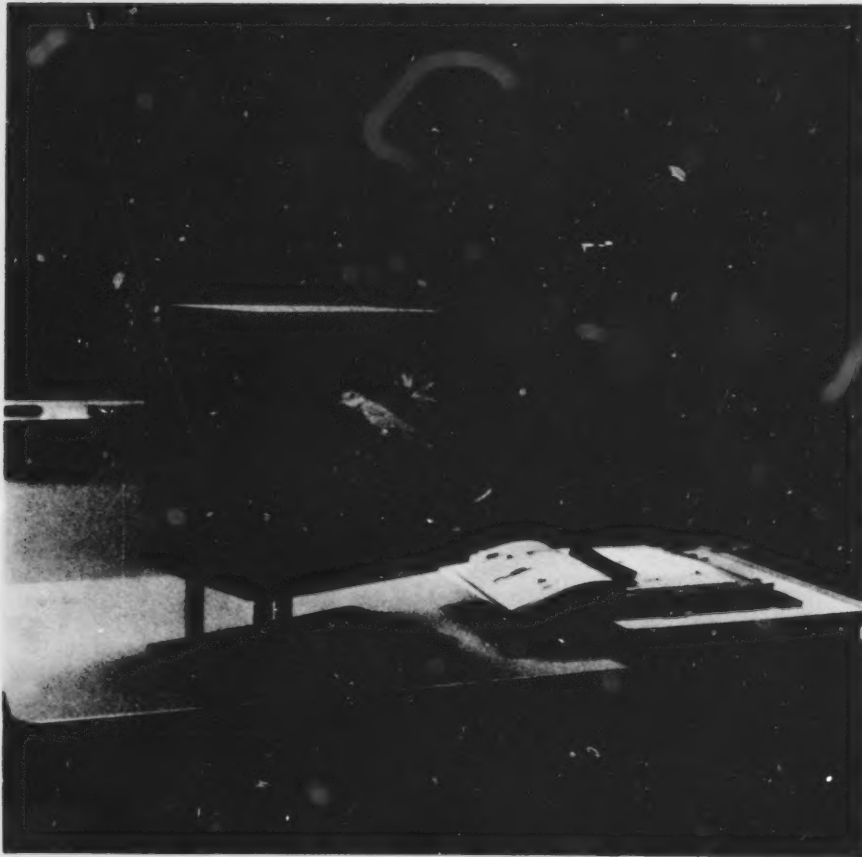


Fig. 1—An ICTS student station

of the monitor stand. As pointed out above, they and the rest of the monitor stand construction permit the X-Y Platform to pass below the monitor; this, in turn, permits the station's camera stand and monitor to be brought closer together than would otherwise be possible.

Figure 2 shows the teacher's station. It differs from the student stations in that its monitor is mounted on top of the housing that contains the master control unit. This housing is located near the desk that supports the station's camera stand. Note that it too is arranged for use by right-handed persons. The room-viewing camera remote control unit can be seen on the teacher's desk directly to the right of the station's X-Y Platform.

The X-Y Platforms of the new ICTS are 2 in. wider than those of the first ICTS. Experience with the first ICTS indicated that a wider X-Y Platform was desirable, because many of the books used by young school children are much larger than we had originally anticipated.



Fig. 2—The teacher's station

THE MASTER CONTROL UNIT

The master control unit is the nerve center of an ICTS in that it controls the source of the image presented on each of the system's TV monitors. By depressing appropriate buttons on the master control unit of the ICTS, the teacher can present material on any of the system's eight station monitors *independently of what is displayed on any other monitor*. The material displayed can consist of any of the following images:

1. A full-screen image of what is being transmitted from any of the system's nine cameras or from its videotape recorder.
2. A horizontally split image from any two of these ten sources.
3. A superimposed full-screen image from any two of these ten sources.

Experience with our first ICTS convinced us to simplify two important operations that occur often: (1) the simultaneous presentation on all eight station monitors of any single or composite image, and (2) a full-screen display on each station monitor of what the camera at that station is viewing. The first operation, called the Ali mode, involves depressing at most five buttons, and the second operation, called the Self mode, requires depressing at most three buttons. Had we used our previous master control unit design, these operations would have required depressing as many as 24 buttons on the control panel.

The power and versatility of an ICTS are due in large measure to its master control unit, and can be better appreciated by an examination of the following figures.

Figure 3 shows the face of the monitor at a student station, displaying a whole-screen superposition of two images. One is the negative image of a bird resulting from a station camera viewing the picture of the bird located on this station's X-Y Platform, and the other is a positive image of the word "bird" resulting from the camera at another station viewing the word "bird" on its X-Y Platform. Note that the monitor screen shown in this photograph could have been at either one of these stations or at any other station, because the master control unit permits the image on any one monitor to be replicated on as many other monitors as desired.

Figure 4 shows another superposition of two images on a station monitor. One is the positive image of a bird and the other the negative image of the word "bird." Note that this superposition can be produced from the one shown in Fig. 3 by merely reversing the polarity of the image or contrast reversal switches on the cameras that are viewing the pictures of the bird and the word "bird."

Figure 5 shows a horizontally split image on a station monitor. The upper half of the image comes from a station camera viewing on its station's X-Y Platform the picture of a bird. The lower half of the image comes from another station camera viewing, on its station's X-Y Platform, someone completing the word "bird." The first of these cameras is transmitting a positive picture and the second is sending out a negative picture. Note that only the upper half of the picture being sent out by the first camera is being displayed on the monitor screen, and only the lower half of what the second camera is transmitting is being shown on this screen.

Figure 6 shows the same composite image, but this time both cameras are transmitting positive images.

Figure 7 shows an amusing superposition of two images. One results from the room-viewing camera viewing the teacher, LeVonne Kelly, and a student standing



Fig. 3—A station monitor displaying the superposition of the negative image of a bird on the positive image of the word "bird"

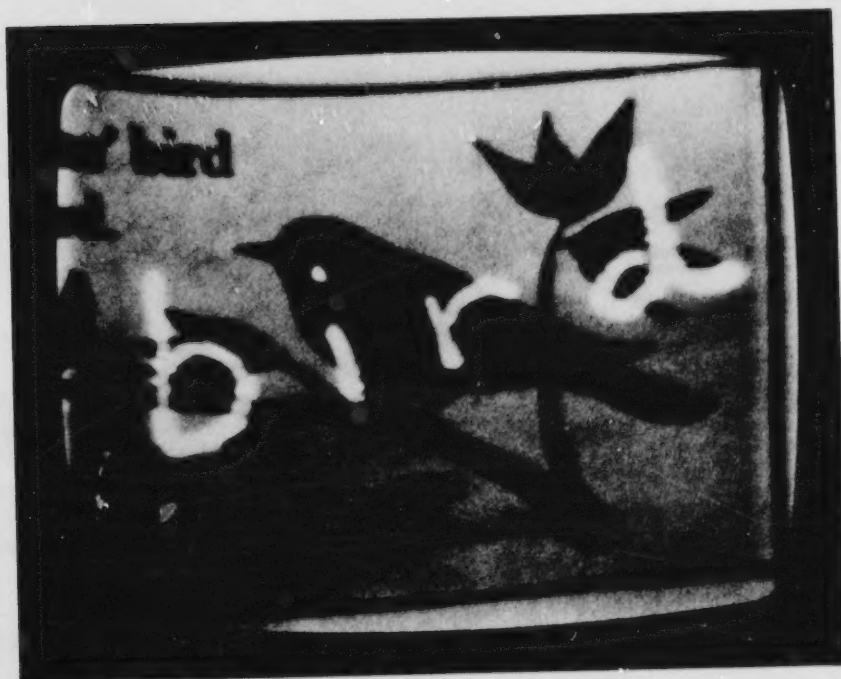


Fig. 4—A station monitor displaying the superposition of the positive image of a bird on the negative image of the word "bird"



Fig. 5—A station monitor displaying a horizontally split image; the upper image is the positive image of a bird and the lower image is the negative image of someone writing the word “bird”

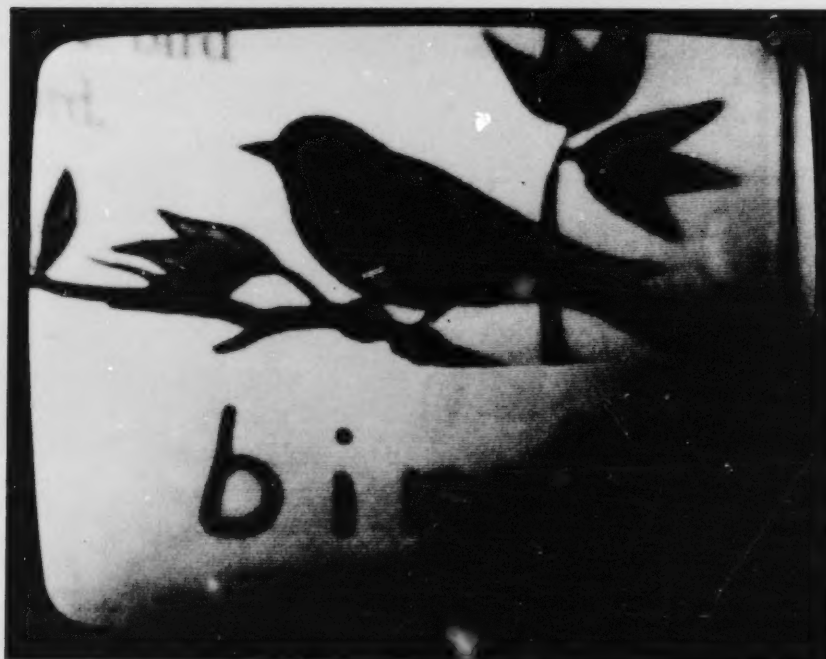


Fig. 6—A station monitor displaying a horizontally split image; the upper image is of a bird and the lower image is of someone writing the word “bird”; both images are positive



Fig. 7—A station monitor displaying a superimposed image of a teacher and student on that of a lowercase and uppercase "O"

in front of the classroom saying the word "Oh!" The other results from the camera at the teacher's station transmitting a negative image of a lowercase "o" and an uppercase "O" from its X-Y Platform. The teacher is standing on the floor and the student is standing on a chair. During the lesson that prompted the taking of this photograph, one of the teachers, Rikk Morris, was seated at the teacher's desk. Using his station camera and X-Y Platform, he first displayed on all station monitors a lowercase and uppercase letter pair. He then asked the students what letter they saw on their monitors. One or more identified the letter correctly. The teacher reinforced the correct response by displaying on each student monitor a superposition of the letter pair and of the other teacher and student being clever with the letter and the sound associated with this letter. Figure 7 shows such a visual reinforcement. The children not only observe the uppercase and lowercase Os on their station monitors, but they also see the faces of their classmate and teacher saying the word "Oh!" Thus, in addition to the phonics lesson, they have the opportunity to see *in detail* the faces of these two people. Without the help of the ICTS, most students would only be able to see the general shape and form of these faces. Thus, we observe that even a simple lesson in phonics can, through the ICTS, become not only a visual and auditory experience in the building of written and verbal communication, but also an adventure in recognizing faces and expressions.

Figure 8 shows a teacher and a teaching aide working with a student at his desk. The single positive whole-screen image shown on the station monitor is being transmitted by the camera at the student's station. Teachers and teaching aides frequently go to a student's desk to work directly with the student. In designing the ICTS, it was never our intention to replace the important personal, one-to-one relationship between teacher and student, but rather we hoped to supplement and support this relationship. Experience in both the Madison and Killian classrooms indicates that the ICTSs have been successful in achieving this important objective.

Figure 9 shows a student learning to play a harmonica by watching his teacher, who seems to be placing his mouth on a sketch of the mouth edge of a harmonica, while inhaling or exhaling at the appropriate times. The image on the student's monitor is a whole-screen superposition of two images. One image is of the teacher as seen by the ceiling-mounted, room-viewing camera; and the other is a negative image of a sketch of the mouth edge of a harmonica, located on the teacher's X-Y Platform.

THE CONTROL CONSOLE OF THE NEW MASTER CONTROL UNIT

The master control unit used in the first ICTS had four banks of switches (one bank for each station). Each bank was composed of a two-row Display Control consisting of six mechanically interlocked switches per row, a two-switch interlocked Special Effect control, a Room Monitor control, and a Record control. Thus, each of the four banks had 16 switches. In addition, there was a four-button Teacher's Channel Selector, which was separate from the master control unit, that could be used by the teacher to choose which station monitor image she wished to replicate on her station monitor. It was possible for the teacher to review quickly what was appearing on any student's monitor (assuming that the brightness and contrast on the student's monitor were adjusted in line with those on the teacher's monitor).



Fig. 8—A teacher and a teaching aide working with a student at his ICTS station



Fig. 9—A student learning to play a harmonica at his ICTS station

Initially, we considered designing the new master control unit in the same way that we had designed the one for the first ICTS. Figure 10 is a sketch of what the control console of such a master control unit would have looked like. The planned dimensions of the unit were 29 by 15 in., with a total of 192 switches. Although we thought that learning the operation of such a control console would not be much more difficult than for that of a four-station system, the larger console would have had a rather overwhelming visual impact. Further, a mechanical switch is noisy when it releases previously depressed switches, and setting up some of the more commonly used ICTS lessons would have required as many as 24 switches to be depressed.

We explored alternate control approaches with the teacher, who had at the time been using the first ICTS for two years and is still using it. As a result, we have designed a simple and reasonably sized control console. As described above, this console is provided with two very useful automatic functions, not available in the original ICTS design, that simplify procedures that occur frequently. This new design retains the same basic control layout for a single bank of keys as the previous design but avoids the repetition of such controls for each of the eight stations.

Figure 11 shows the control console of the new master control unit (NMCU). Note that the buttons are grouped into several distinct arrays, including the 2 by 3 array (two rows and three columns) of buttons labeled Mode, the 2 by 10 array labeled Display Control, the 2 by 1 array labeled Special Effect, and the 1 by 8 array labeled Station Selector. The use of these and other lights and buttons on the control panel of the NMCU is described in detail in App. A, but a few words are in order here to explain what is accomplished when the buttons in each of the major arrays are depressed. The control console is equipped with two rows of Mode and Display Control buttons to construct and display both horizontally split and overlaid or superimposed images on the system's station monitors and to do this either on one monitor at a time or on all eight monitors simultaneously.

Mode Buttons

The Mode buttons do not have a counterpart in the previous master control unit. They evolved from our discussions with Jadeane von der Lieth, teacher of the visually handicapped at the Madison School. These buttons determine whether images on each of the system's station monitors are to be composed independently of one another (the MANUAL buttons), whether every station monitor is to display the same thing (the ALL buttons), or whether each station monitor is to display only what its station's camera is viewing (the SELF buttons). Only one button in each row of Mode can be depressed at a given time. Two Mode buttons will be illuminated at all times but they need not bear the same label.⁵ Thus, not only is it possible to use the ICTS in one of its three pure modes, namely, Manual-Manual, All-All, and Self-Self, but it is also possible to use it in any one of its mixed modes. For example, the user can select the ALL button in the upper row and the SELF button in the lower row. If he then selects T in the upper row of the Display Control, and SPLIT as the Special Effect, the monitor at each station will show the upper half of the

⁵ In general, when an NMCU button is depressed, it becomes illuminated. Exceptions are discussed in App. A.

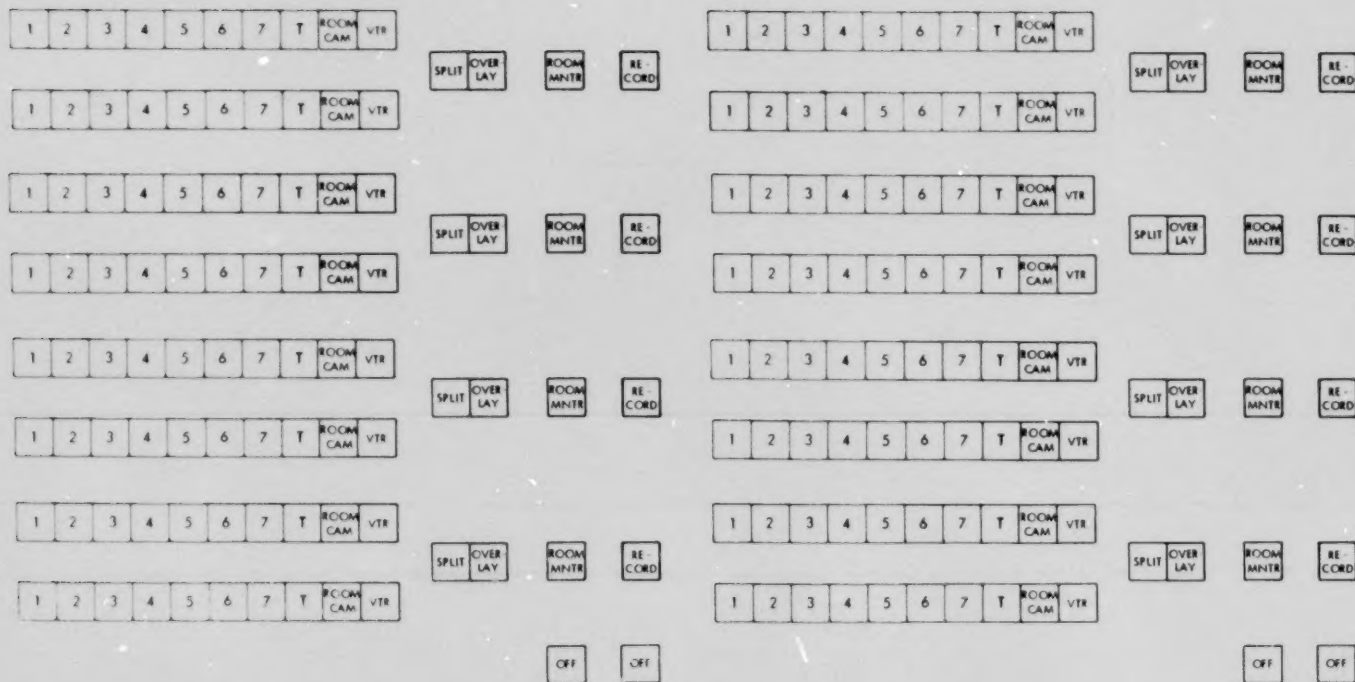


Fig. 10—A sketch of a control console for an eight-station ICTS that was considered but abandoned because of its complexity

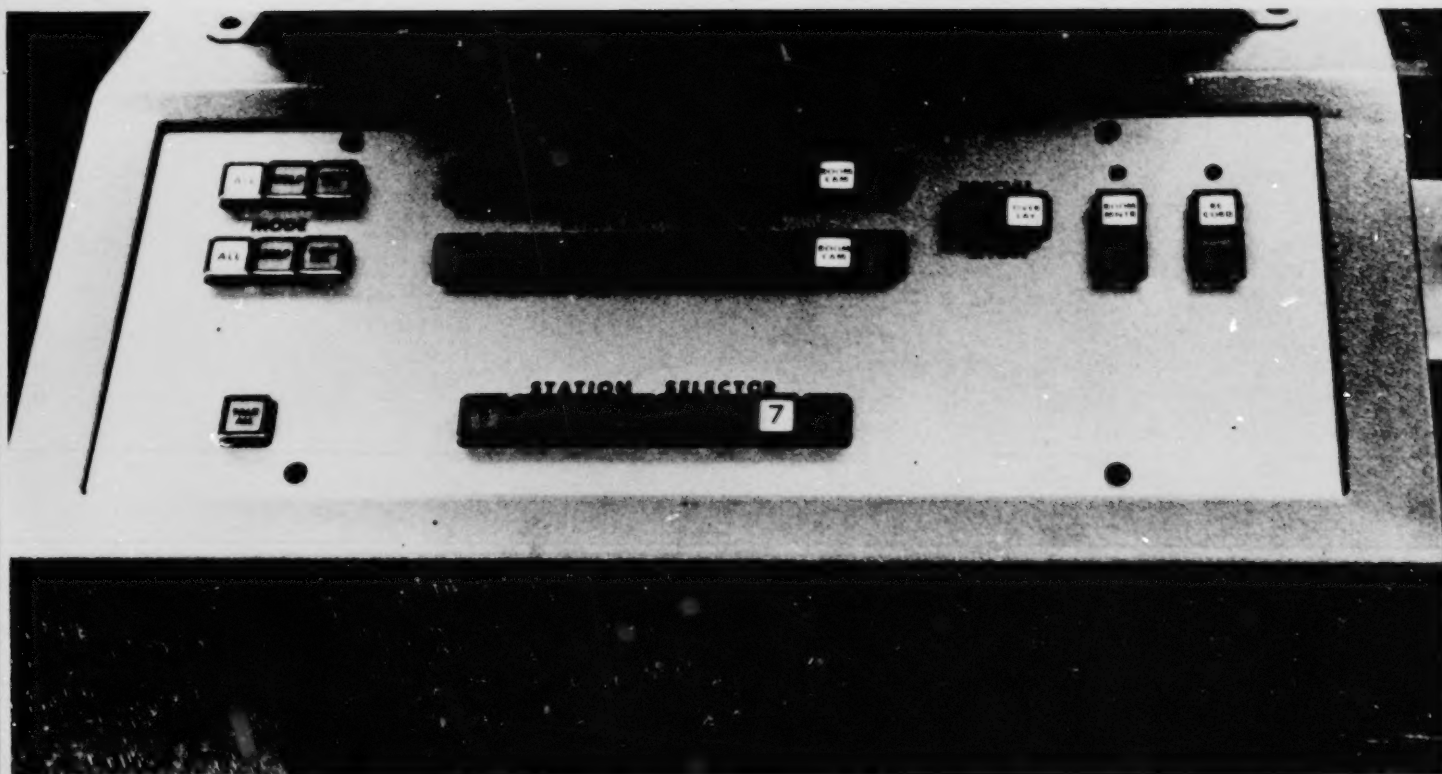


Fig. 11—The control console of the eight-station ICTS

image being transmitted by the teacher's camera on the upper half of the screen, while the lower half of the monitor will show the lower half of the image being transmitted by the camera at the user's station.

Special Effect Buttons

These buttons determine whether the image on a station monitor is to be a horizontally split image from either one or two of the system's nine cameras or from its videotape recorder (SPLIT button), or whether it is to be a whole-screen superposition of the output from either one or two of these ten sources (the OVERLAY button). The Special Effect buttons determine whether the image on a particular monitor is to be composed through a split or an overlay, but they do not determine whether that split or overlay is to result from the use of the output from two distinct sources or from only one. The latter is determined by which buttons are illuminated in the Display Control. Only one of the two Special Effect buttons can be depressed at a given time.

Display Control Buttons

These buttons determine the source(s) of the image displayed on a station monitor. When the SPLIT button in the Special Effect is illuminated, the depression of a button in the upper row of the Display Control, in general, causes the upper half of the picture being sent out by the camera (or videotape recorder) that corresponds to that Display Control button to be displayed as the upper half of the image appearing on the monitor at the station that bears the same alphanumeric designation as that on the illuminated button in the Station Selector. When the OVERLAY button in the Special Effect is illuminated, the depression of a button in the upper row of the Display Control, in general, causes the picture being sent out by the camera (or videotape recorder) that corresponds to that button (1) to be displayed on the monitor at the station that bears the same alphanumeric designation as that on the illuminated button in the Station Selector, and (2) to be superimposed on the image being sent out by the camera (or videotape recorder) that corresponds to the button that is depressed in the lower row of the Display Control.⁶ The exceptions to these general statements about the Display Control are explained in App. A. Only one button in each row of the Display Control can be depressed at a given time, but the depression of a button in one row does not affect the depression of any button in the other row.

Station Selector Buttons

These buttons allow the user to select which station's status is to be displayed on the control console or is to be manipulated through the console. When a particular button is depressed in the Station Selector, buttons in the Display Control and Special Effect will light up to indicate what the last image composition had been for the station corresponding to the depressed button. Further, the video going to this station's monitor is also sent to the teacher's monitor, so that the person at the teacher's station can see the same material that is being displayed on the monitor

⁶ This and the previous sentence are also valid if the words "upper" and "lower" are replaced, respectively, by "lower" and "upper."

at the station that corresponds to the illuminated button in the Station Selector. Thus, the Station Selector also performs a function that is similar to that performed by the Teacher's Channel Selector of the first ICTS. If the user now makes a change in the image composition, the result of that change becomes apparent immediately, both by changes in the illumination of buttons in the Display Control and the Special Effect and by changes in the image on the teacher's monitor and on the station monitor corresponding to the depressed button in the Station Selector.

When the Manual-Manual mode is selected, the Station Selector buttons also determine which particular station monitor image can be altered by the buttons in the Special Effect and the Display Control. Only one button in the Station Selector can be depressed at a given time.

On entering the All-All mode, lights in the Display Control and the Special Effect are turned off to indicate that a decision must be made as to which of these buttons to depress. When the buttons are depressed, they are illuminated, and the resulting image appears on all the eight station monitors, regardless of which button happens to be illuminated in the Station Selector.

On entering the Self-Self mode, those buttons in the Display Control are illuminated that bear the same alphanumeric designation as the illuminated button in the Station Selector, and the Special Effect buttons are dark. The subsequent selection of the Special Effect manifests itself on all eight station monitors, and the button depressed is illuminated. Further, while in the Self-Self mode, depressing buttons in the Display Control will not produce any changes in the images displayed on the eight station monitors or any change in the illumination of buttons in this control.

The depression of a numbered button in the Display Control can be interpreted as permitting all or part of the image output, from the camera at the station that bears the same number as the depressed button, to be displayed on one or more station monitors. The depression of the T, ROOM CAM, or VTR buttons in this array permits, respectively, all or part of the picture from the camera at the teacher's station, from the room-viewing camera, or from the videotape recorder to be displayed on one or more station monitors. Each numbered button in the Station Selector refers to the station that bears the same number, and the T button in that control refers to the teacher's station.

MASTER CONTROL UNIT AUDIO CAPABILITIES

Initially, with the first ICTS, we made no provisions for audio between the teacher and the students. We felt it would not be needed with a four-station system because the teacher and students could be located close to one another. Later, however, we added a simple audio amplifier so that all students, through a speaker or earphones plugged into their stations, could hear and control the volume of the audio portion of material being played back on the videotape recorder.

In the new ICTS, a microphone and a speaker are a part of each station. The audio function of a station is activated by depressing the button in the Station Selector that corresponds to this station. This puts the station into two-way audio communication with the teacher's station; that is, the teacher can hear what the student is saying, and the student can hear what the teacher is saying. In addition, if the teacher wishes to work privately with a student, both the teacher and the

student can wear headphones, which, when plugged into the jack on the front of their speaker boxes, replace the speaker. Each station has an independent volume control for the speaker or for the headphones.

When a station is set to watch the videotape recorder, the audio portion of the recording is automatically sent to this station's speaker. Again, listening in private is possible by using the headphones. When a student's work is being recorded, the audio from the microphone located at the student's station is automatically sent to the audio input of the videotape recorder. When the Station Selector is set to the station being recorded, the sound from the teacher's microphone is also recorded.

The new ICTS has an additional audio control, the TALK ALL button. It is shown in the lower left-hand corner of Fig. 11. When depressed, this button lights up and locks in the depressed position. Using the microphone at the teacher's station, the user is able to talk to all of the students at the same time through the speakers at their stations. However, only one student can talk to the teacher at one time, namely, the student located at the station that corresponds to the illuminated button in the Station Selector. When the TALK ALL button is depressed a second time, it is released and its light goes out.

THE ROOM-VIEWING CAMERA

The room-viewing camera is a GBC CTC-6000 and is equipped with a 10 to 1 zoom lens. (See Fig. 12.) Its mount is attached to the ceiling of the classroom and it can "see" virtually any part of the room. It is operated by a remote control unit that, through a joy stick having two degrees of freedom, governs its pan and tilt. Three switches, which lie in a row directly below the joy stick, govern, respectively, the aperture of its zoom lens, the focus of the lens, and the magnification that it provides. Another switch changes the picture provided by the camera from positive to negative and vice versa. The speed with which the room camera pans or tilts is roughly proportional to the distance that the joy stick, governing these motions, is moved from its central position. The rate at which components of the zoom lens respond to the control unit's switches is governed by a speed control knob. Because the classroom that houses the new ICTS is very large, three receptacles have been provided that permit the remote control unit to control the room-viewing camera.⁷ One is at the teacher's desk, another is near a chalkboard, and the third is near the room monitor/receiver.

THE ROOM MONITOR/RECEIVER

The room monitor/receiver of the new ICTS is a KV 1910 19-in. Sony color receiver. Like any other color TV receiver, it is used to display off-the-air color or black and white TV programs. It is also used to display color or black and white TV programs that are being recorded by the ICTS's videotape recorder, and to

⁷ The classroom is approximately 64 by 32 feet, but roughly half of this area is occupied by tables, chairs, and sandboxes, where the children eat lunch and play games, and by open space where they sing, exercise, listen to stories, etc. The ICTS occupies approximately 600 square feet at one end of the room. (See Fig. 13.) The classroom area is spacious even with eight stations when compared with the area occupied by the first ICTS, which had only four stations (see Fig. 14).

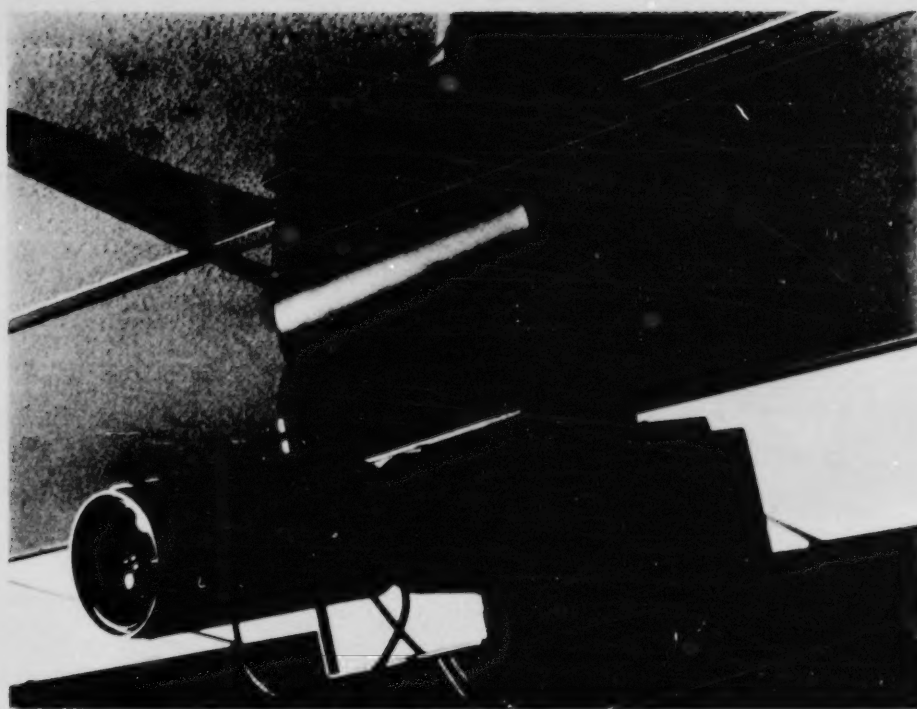


Fig. 12—The room-viewing camera

display in black and white what is being shown on one or more of the ICTS's station monitors.

The room monitor/receiver sometimes is viewed by small groups of students. However, only those students who can see in sufficient detail the image on its screen (at distances that do not interfere with other students grouped around and watching it) can participate successfully in this activity. Figure 15 shows three such students watching a sequence from "Electric Company," a Children's Television Workshop production.

The room monitor/receiver can be used independently of the rest of the ICTS, including the videotape recorder. This is easily accomplished by flipping a switch on the back of the monitor/receiver to the 300-ohm position, which connects the room monitor/receiver to an external antenna. The monitor/receiver's tuner can then be used to select off-the-air TV broadcasts.

When the switch on the back of the monitor/receiver is in the 75-ohm position and the monitor/receiver is tuned to channel 6, it acts like a TV monitor; when this switch is in the 300-ohm position, it acts like a TV receiver.

THE VIDEOTAPE RECORDER

The new ICTS's videotape recorder is a JVC 6100. It is much more versatile than the videotape recorder in use with our first ICTS. Both videotape recorders



Fig. 13—The eight-station ICTS at Killian Elementary School,
Rowland Heights, California



Fig. 14—The four-station ICTS at Madison Elementary School,
Santa Monica, California



Fig. 15—Students gathered around the room monitor/receiver

can (1) record what is displayed on a station monitor and what is being said at or near the station of which that monitor is a part; and (2) play back, on one or more station monitors or on the room monitor/receiver, what was recorded previously on the system's videotape recorder or on another videotape recorder, including both the video and audio portions of the recording. Both ICTS videotape recorders can record or play back in color or black and white. However, because the first ICTS has no other color TV equipment, the ability of its videotape recorder to record and play back in color is not important. Unlike the first ICTS's videotape recorder, the JVC 6100 can record off the air and is equipped with a timer that permits it to record, completely unattended, at a predesignated time. Further, it can make recordings of off-the-air material regardless of whether the color TV monitor/receiver is turned on or off. Note that having a color TV monitor/receiver as part of the new ICTS makes the capacity to record and play back in color very worthwhile.

With both the first and second ICTSs, the videotape recorder is used to record classroom activities such as a student working by himself, student-student interactions, and student-teacher interactions. These videotapes are used by the teachers to analyze student progress and problems, teaching techniques, and participant interactions. The videotape recorder is also used to prepare lessons, in whole and in part. For example, it can be used to experiment with visual and auditory learning techniques, many of which would not have been considered possible when working with partially sighted children before the development of ICTSs. Further, the presence of compatible videotape recorders in the two participating classrooms makes it possible for the teachers in these classrooms to share videotaped materials.

II. DESIGN AND IMPLEMENTATION CONSIDERATIONS

In this section we will describe the electronic switching system, more or less conceptually, to aid those considering constructing an ICTS. A complete set of logical drawings and other more specific circuit details are available from the authors and will be supplied on request.

OVERALL ORGANIZATION

In the control console, the electronics are organized in a modular fashion according to function. There is an input/output board, which provides conditioning of the video signals coming into the system and special video output signals, and eight station boards (each assigned to a particular station) that control the video going to each station. There are two audio boards that control the audio and provide sufficient amplification of the audio signals to drive the speaker located at each station. There is also a sync distribution board that develops the appropriate signals for camera and monitor synchronization, as well as other necessary video conditioning signals. Further, associated with the master control unit's keyboard is all of the control logic that develops the appropriate sequences of control signals each time a button on the control unit is depressed.

It will be useful to describe briefly the physical structure of the circuit boards and how these boards are connected to the rest of the system. The electronic components, primarily integrated circuits for various functions to be performed, are located on an epoxy-fiberglass board, and the wiring between these components is provided either by printed conductors on the board or by conventional wires. Figure 16 shows both sides of a printed circuit board used for video switching in the ICTS. The black oblong objects are the integrated circuit elements, the gray lines are the printed circuit wiring, and the black lines are wires that were added to the original board to provide a functional capability that we had not anticipated. The signals to and from the other parts of the system that are not located on a board are carried by wiring connected to the board via electrical contacts (edge connector pads) arranged along both sides of one end of the circuit board. In this design, provision has been made for up to 62 external connections to each of the major circuit boards. Each board can then be inserted into an edge connector, that is, a special type of socket through which contact is made between the external wiring and the wiring located on the circuit board. Note the edge connector pads and the circuit connections to these pads. The pads make contact with the external wiring in the edge connector. In addition, the edge connector and a set of physical guides provide support for the circuit boards, which are usually arranged side by side as books on a shelf. On the back side of an edge connector, each contact is connected to the "back panel wiring," which distributes signals to other boards or, via cables, to external elements such as a camera, monitor, or the logic in the master control unit. Signals can be high- or low-level logical control signals, the high-level signals corresponding to "ones" and the low-level signals corresponding to "zeros." They can also be analog signals of a video or audio nature. Most of the back panel wiring

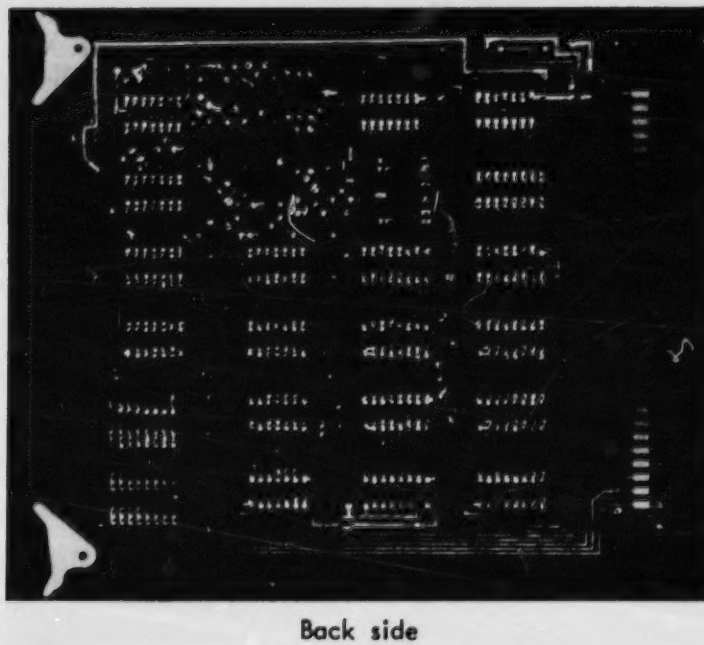
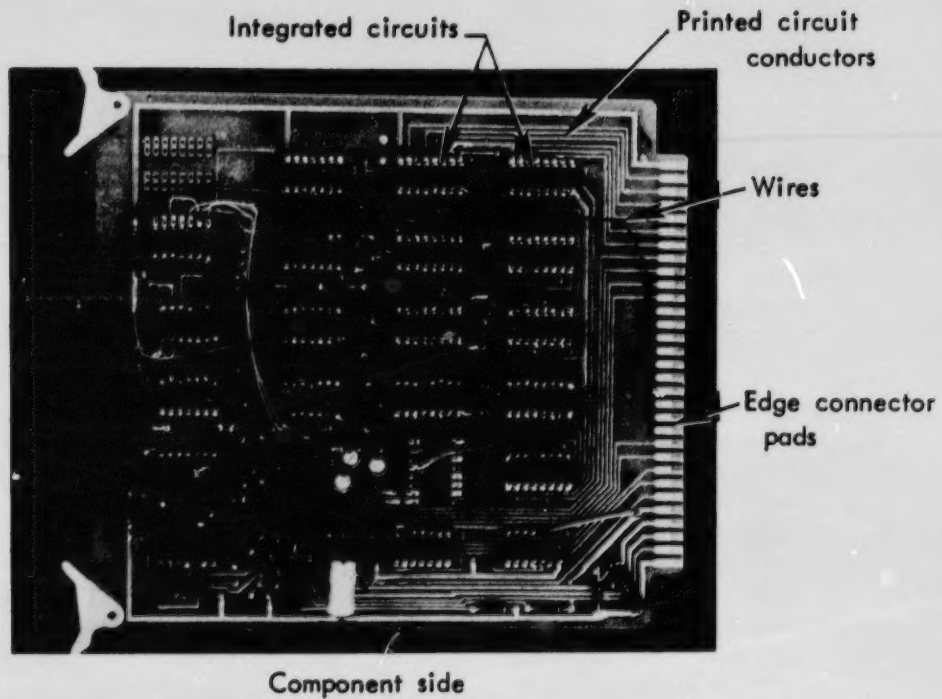


Fig. 16—Printed circuit board used for video switching in the ICTS

is in the form of a bus structure, consisting of a large number of lines, each of which connects the corresponding points of each connector. It is a very economical way to provide communication between functional units in electronic systems.

A few words about the electronic components are in order to help follow the discussion of electronic switches, memory, and the performance of various kinds of logic. Integrated circuits (ICs) are used to perform a very wide range of functions. They are usually available in a package about $\frac{3}{8}$ in. wide, 1 in. long, and about $\frac{1}{4}$ in. high. This package has either 14 or 16 external connections, at least two of which must be used for power. The rest are available to perform useful functions, and in practice they are very seldom left unused. The power required by ICs is extremely low, so that in spite of having the equivalent of perhaps 70,000 transistors in the ICTS, no extra ventilation is needed to remove heat. In fact, heat from the ICTS's control system is barely perceptible.

THE INPUT/OUTPUT BOARD

The video signals from all the cameras and from the videotape recorder are brought into the input/output (I/O) board where they can be adjusted to the same amplitude before they are sent to the station boards via the bus system described above. In addition to adjusting the magnitude of the video signals, a contrast reversal circuit on the I/O board has been provided for the video from the room camera. Thus, a positive or negative contrast image from the room camera can be selected by an electronic switch located on the I/O board, which is controlled by the contrast selector located on the room camera control unit.

The video signal from the videotape recorder is amplified slightly to bring it up to the level of the other signals. In addition, the sync signal on the videotape recorder output is removed before it is sent to the station boards. The amplified video signal (with sync) is also sent to the synchronizing system so that all cameras can be electronically locked in step with the videotape recorder. However, if the Record line is active, this connection is broken to prevent the synchronizing system from seeing its own signal and going into fibrillation.

The output section of the I/O board controls the processing of the video signals from the appropriate station boards and sends them to the teacher's monitor, to the room monitor, and to the videotape recorder when recording is taking place. To accomplish these functions, there are three video buses coming into the I/O board. As explained below, there are three electronic switches on each station board that control whether the video from this board is to be connected to one or more of the three buses so that it can be sent to the teacher's monitor, the room monitor, or to the videotape recorder. In going through the output section of the I/O board, the video signals are conditioned by a blanking signal, and sync is added to the video. The final output goes through a cable to the appropriate destination, for example, the teacher's monitor.

THE STATION BOARD FOR VIDEO SWITCHING

The control approach in the first ICTS used mechanically interlocked switches which, when depressed, became illuminated and stayed in the depressed position.

When depressed, the switch simultaneously released the previously depressed switch in that part of the control unit. Thus, when a new visual display was selected for a particular student, switches that governed the previously selected display were disconnected. The advantage of this approach was that the switches provided the memory of the composition of the image selected for each student. Although the memory was provided by the mechanical switch, the video signals were actually switched by small relays located on the equivalent of station boards in the first ICTS. Similar switches would remember, for example, which student monitor picture was being recorded, which was being seen on the room monitor, or which student's work could be observed on the teacher's monitor. This mechanical memory was very useful. However, as pointed out above, when considered for an eight-station ICTS, mechanical switches proved to be far too cumbersome in operation.

In the new ICTS, we have provided the electronic equivalent of the mechanical memory that governs the use of the entire Display Control section for each station, including the automatic mode functions described above. To accomplish this, we built eight independent but identical circuit boards, one for each station in the system. In essence, each board provides the electronic equivalent of the mechanical memory of a bank of switches that control a station in the earlier master control unit.

Through the use of integrated circuit elements, each board provides memory of the current state of the Display Control for the station served by this board. All of these boards have connections to 14 digital data input buses that are used to signal, to the appropriate board(s), what changes are to be made in the electronic memory contained on each board. The data lines or buses are common to all eight station boards, but there is a separate Station Select line for each board. The Station Select line can be active for only one board at a time, namely, the one associated with the station selected on the control console. This is the only board that will be able to respond to the changes indicated on the data lines. These changes are stored in the electronic memory on the board corresponding to the selected station, and this memory is used to control the routing of the video signals through the board.

Figure 17 is a diagrammatic sketch of the logic and video paths within a station board. There are two four-bit memories, MA and MB, that control the electronic switches SA and SB. These two memories obtain the information they are to store from the four Display Control data lines or from the internal Self data lines depending on the state of the Self control line. The four bits stored in this memory can select one out of as many as 16 different video switches; however, only ten were required. The electronic switches, SA and SB, are able to decode the four bits from their respective memories and connect the appropriate one of the ten video input signals to the output section of this switch. The other nine video signals are well isolated from the output section of the switch. In addition, the one-bit Special Effect logic and memory determines whether both switches, SA and SB, will be on all of the time, creating a superimposed image, or will alternate appropriately, with one on and the other off, creating a split image.

An example may help clarify this discussion. Suppose the system is in the Manual-Manual mode and the teacher wishes to allow the student at station 3 to see part of what the teacher's camera is looking at on the lower half of the screen and part of what the student's station camera is viewing on the upper half of the screen. The teacher selects station 3 on the Station Selector, which activates the

Station Select line to the circuit board assigned to station 3; all the Station Select lines to the other boards are inactive. The teacher then pushes the button labeled 3 in the upper row of the Display Control. By way of the master control logic, the four Display Control Bus lines, regarded as an ordered set, assume the values low, low, high, and high which corresponds to a binary value of three. Recall that the convention used here is that a low corresponds to a "zero" and that a high corresponds to a "one" in binary notation. Because the system is in the Manual-Manual mode, the Self and All lines are low, or inactive, and exert no direct control; therefore, the Load Control Logic to the Data Control Gate is low and the data on the Display Control Bus are allowed to pass through the Data Control Gate to memory A and to memory B. Up to this point, nothing has changed within the memories located on board number 3. A small fraction of a second after the data values are present on the Display Control Bus, a momentary Load A signal is generated by the master control logic. This signal is sent to all station boards; but it is only in the board with an active Station Select line that the Load Control Logic allows the Load A signal to set the four bits of memory A to the value 0011. These data values are stored in memory MA. The outputs from memory MA are inputs to the control section of electronic switch SA, and are inputs to the A section of the Data Output Gates.

The electronic switch SA decodes the pattern 0011 and connects video input 3 to the output of SA. All other video inputs to SA are prevented from getting through to the output. This output then goes to one of the two inputs of the Mixing Amplifier.

At the Data Output Gates, digital signal levels equivalent to the data values of 0011 are allowed to be coupled through to the Display Control Light Bus under control of the Station Select line. Remember that since only the Station Select line for the board assigned to station 3 is active, and all others are inactive, the output data from any other board are prevented from appearing on the Display Control Light Bus. The values on this bus are decoded by the master control logic and turn on the light under button 3 in the upper row of the Display Control.

When the teacher depresses the button labeled T in the second (or B) row of the Display Control, the value on the Display Control Bus becomes 1000, a binary value of 8, which in the ICTS is interpreted as T. In this case, a Load B signal occurs on the input control. Memory MB is loaded with the value 1000, switch SB connects T to its output, and so on.

The teacher now chooses the special effect that is desired for station 3, say, a split image. On pressing the SPLIT button, a momentary signal will appear on the Split line shown in Fig. 17. Because the Station Select line is active to board 3, and to no other board, the Special Effect Logic will be set to provide a split image to station 3. The Special Effect Logic will continue to provide a split until both the Station Select and the Overlay lines are active on the board for station 3. As mentioned above, the Special Effect Logic is able to turn the electronic switches on or off, in addition to the normal action of the switch that selects one of the several inputs to be connected to the output.

The video output from each of the two switches, SA and SB, is brought into a Mixing Amplifier, a single integrated circuit, whose output goes to the output section of the board where synchronizing signals are added. The resulting composite video signal is then sent out through the cables to the monitor located at the station associated with the particular board.

In addition, the output from the Mixing Amplifier is sent to three separate electronic switches, all within a single integrated circuit labeled SC, located on the same station board. These switches control whether this station's video output is to be routed to the Record Bus, the Room Monitor Bus, or the Teacher's Monitor Bus. The switch for the Teacher's Monitor Bus is controlled by the Station Select line discussed above. When this line is active (remember that it is active for only one station at a time), the video signal from this board is sent to the I/O board for signal conditioning and then to the teacher's monitor. Thus, the teacher can see the image content that is being displayed on the monitor at the station selected by the Station Selector. To replicate on the room monitor the image being displayed on a particular station monitor, this station must first be selected on the Station Selector; that is, its Station Select line must be active. When the ROOM MONITOR button on the control console is pushed, the Room Monitor control line becomes active and, together with the Station Select line, sets the Room Monitor memory on this board to an active state. This memory controls the associated electronic switch that sends video to the Room Monitor Bus from that particular station board.¹ A similar sequence of actions occurs when the teacher decides to record the image being sent out to a particular station.

The signals to the teacher's monitor, the room monitor, and the videotape recorder (for recording) are not sent directly to their destination but, as described, are routed via back panel bus wiring to the I/O board, where the signal levels can be adjusted and where appropriate blanking and synchronizing signals are inserted. Then, from the I/O board, system cables carry the signals to their proper destination.

The two automatic modes, Self and All, are handled differently because each of them, in their own way, controls every station. When an ALL button is selected, in either row of the Mode switches, the button is lighted and the previously selected Mode button is turned off. The light in the same row of the Display Control is also turned off to indicate to the user that a Display Control selection in this row must be made. However, until a selection is made, the last selected video source continues to be sent to each station. In addition to turning off the Display Control light, the Special Effect light also goes off to indicate that a selection must be made there too. These operations are all carried out by the logic that is part of the master control unit.

There is an input line to each station board that is similar in function to the Station Select line, except that this line is controlled by the All mode master control logic and goes to all boards. When the All line is active, and a Display Control selection is made for the corresponding row, the appropriate address appears on the four data lines and is subsequently loaded into the corresponding memory on every board. Similar logic is used to control the Special Effect memory on every board.

Returning to the example above, suppose that the teacher now wishes to display student 5's work on the bottom half of each station monitor screen, and part of the output from the room camera on the top half of the screens. First, the teacher selects the All mode for each row of the Display Control. The master control logic

¹ Immediately before the Room Monitor control line becomes active, a Room Monitor clear line is momentarily activated that turns off the previously selected Room Monitor memory on any station board.

then turns off the lights in both rows of the Display Control and in the Special Effect control of the master control unit. No change will have occurred yet in any of the station boards except that the All Bus will be active. Recalling the previous portion of this example, nothing in the memory of station board 3 will have changed and its Station Select line will still be active. The video seen on the monitor at station 3 will still be from camera 3 on the top half of the screen and from the teacher's camera on the bottom half of the screen. Although the data on the Display Control Light Bus correspond to this image composition, the master control logic has turned the lights out as outlined above. Note that all of the other station monitors are also displaying what they were displaying before the ALL buttons were depressed.

When the teacher chooses ROOM CAMERA in the upper row of the Display Control, the Data Control Bus will be set to a value of 1001 or 9. Then the momentary Load A signal will appear and, together with the active All line, will cause memory A on all boards to be set to 1001. Switch SA decodes the value 1001 and connects the video from input 9 (the room camera) to the output. At this point, each station monitor is displaying all or part of the output from the room camera, depending on what the last Special Effect selection was for that station. Meanwhile, the light in the upper row of the Display Control has been enabled and the light in the ROOM CAMERA button will go on to indicate that the room camera has been selected for station 3. Because we are in the All-All mode, the teacher will know that each student has the same selection for the upper part of the Display Control.

When 5 is selected in the lower row of the Display Control, the sequence is similar, except that the Data Control Bus will have the value 0101 or 5 and the Load B will be activated. Next, when the SPLIT button is selected, the Special Effect Logic on every board is set to split. As a result of these operations, the appropriate lights in the control unit are enabled.

Similarly in the Self mode, the Self Bus goes to all the boards. However, when this line is active, the data input lines to the appropriate four-bit memory are electronically switched so that they are connected to internal data lines that are unique to each board. These have been prewired, although they can be easily changed, to provide data values that correspond to the station that each board is to serve.

The lights in the push buttons are controlled by 11 output data buses or lines that are connected in parallel to each of the boards. When the Station Select line to a board is active, these output data lines are connected by the Data Output Gates (shown in Fig. 17) to the various memory cells on the board. The data on these lines are then used to control which lights in the control console are able to be turned on (which depends on the All or Self conditions described above) to indicate the status of this particular station. When a different station is selected on the Station Selector, a different Station Select line becomes active, and the data on the output lines will change to correspond to the status of the newly selected station board.

THE AUDIO SWITCHING SYSTEM

In implementing the switching for the audio portion of the system, we used many of the same concepts and the same type of logic as in the video switching boards. There were, however, some significant differences in the signal levels. A TV camera puts out a nominal signal of about one volt, while a typical microphone

produces signals that are about one-hundredth of this value or less. To avoid interference or noise problems, we provided a preamplifier within each of the camera stands that raises the level of the microphone signals to about one-tenth of a volt before being sent over the system cables to the audio switching and control boards. Since we had to work with relatively low-level signals, careful attention was paid to the electronic design of the audio system because of the possibility of cross talk (the coupling of unwanted signals from one line into another).

The remaining electronics for the audio system were separated by function into two circuit boards, one for the switching of audio signals and the other for the final amplification to levels adequate to drive a speaker at useful volumes. The availability of integrated circuits made it possible for us to house both the preamplifier and the final power amplifier in a very small area of a printed circuit board.

The switching of the audio signals from the seven microphones at the student stations to the teacher's speaker, under control of the Station Selector, and the switching of the appropriate microphone to the audio input of the videotape recorder for recording, are accomplished by using a rather simple modification of the same circuit board used for the switching of video signals. Figure 18 is a diagram of the resulting circuit for this portion of the audio switching. A comparison of this figure with Fig. 17 shows that the necessary major changes involved leaving out many of the logic and control functions required for video switching. As described above, the video board has two four-bit memories that control two multiple input-single output electronic switches. Instead of combining the two outputs from these switches, each output is used to drive an independent amplifier. The input signal lines to these switches are the eight preamplified audio signals from the microphones at each station. The output from one switch and its amplifier drives the speaker located at the teacher's station. The output from the other switch is routed to the audio input of the videotape recorder. The control of these two switches does not employ the same data lines used for the video switching. In this case the four bits on the data lines represent, in binary code, the station selected on the Station Selector and not the Display Control data that were used for the video switching. The teacher's audio section of the switch uses these four bits directly because it is not necessary to remember them. However, the record memory, MB, will remember the four bits on the data line whenever the RECORD button is pushed. Recall that when the RECORD button is pushed, a Record Clear occurs first and then the Record line becomes active. The Record Clear clears the memory and the Record line loads the four bits into this memory. Subsequent changes of the Station Selector will not change the value in this memory unless RECORD is pushed again, or RECORD OFF occurs, which simply activates the Record Clear line.

Switching control of the audio from the teacher to the students required a somewhat different approach to provide a capability for Talk All. A similar one-to-many capability had to be provided for the audio coming from the videotape recorder (when it is in playback mode) for any of the stations selected to view the videotape recorder output (via either the upper or lower row of the Display Control). For teacher-to-student audio, seven independent electronic switches are used to connect the teacher's microphone signal to seven independent audio amplifiers, each of which drives the speaker located at a different student station. Each switch is controlled by the Station Select signal mentioned above, or by a signal from the TALK ALL switch. Remember that the Station Select signal can be active only for the station that has been selected on the Station Selector so that the teacher will

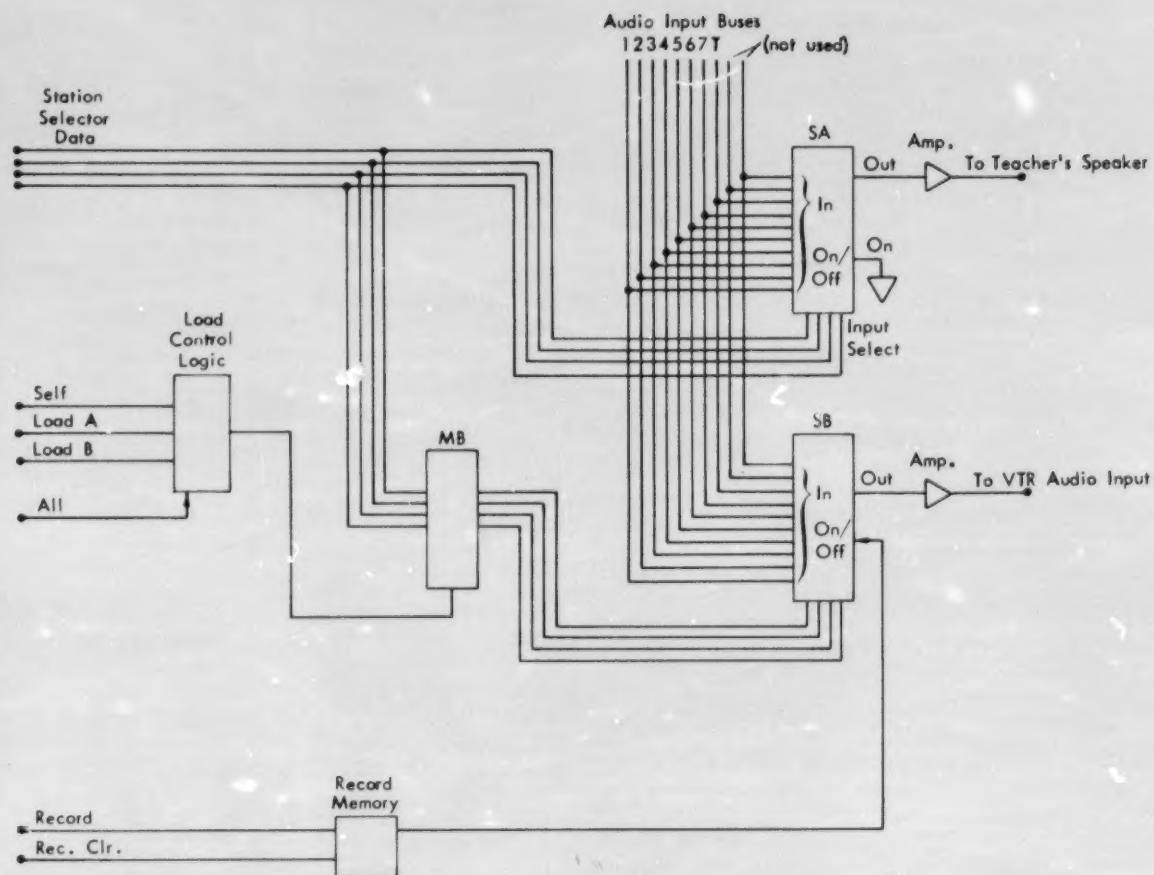


Fig. 18—Circuit used for audio switching

be heard through the audio system only at this station. However, when TALK ALL is selected, all seven electronic switches are closed.

To handle the videotape recorder audio switching problem, additional logic was incorporated on each of the video channel boards. This logic determines whether memory MA or MB on the board contains data values that correspond to the selection of the videotape recorder for the station served by this board. A signal indicating this condition is sent to the audio board to activate an electronic switch that allows the audio from the videotape recorder to be sent to the station's speaker. The audio switching for this function uses eight independent electronic switches (in two integrated circuits) and is very similar to that used for the teacher-to-student audio described above, except there the Talk All was required.

SYSTEM SYNCHRONIZATION

Because of the use of special effects, each camera and each monitor must run in synchronism with each other. In addition, the use of a videotape recorder requires that we be able to synchronize the entire system to an external source of video. We initially designed our own system for this purpose, using a variety of integrated circuits available commercially. Although the system we built worked, it did not perform acceptably with the videotape recorder. There was instability in the horizontal sync from the recorder, which made each vertical line swing like a rope. When we were designing and building the first ICTS, we had been warned that this might occur, but we avoided the problem by using a broadcast quality commercial sync system and by modifying other system components, such as the monitors. This was the solution we finally adopted for our second ICTS, using a Grass Valley Model 950 Sync Generator. The original circuit we designed is still intact, and the system is able to use it by replacement of a single integrated circuit, but the videotape recorder cannot then be used with the system in playback mode.

Horizontal and vertical drive signals that keep all of the cameras in step with each other are sent to pulse amplifiers located on the sync board, and thence to each of the cameras in the system. Composite blank and composite sync signals are distributed through the back panel wiring to the station boards and to the I/O board.

The signal for creating the split screen effect is generated by counting the number of horizontal scan lines that have occurred since the last vertical retrace took place. When this count reaches a value that is one-half of the total number of lines that make up a full picture, an integrated circuit, called a flip-flop, changes state. It stays in the new state until the vertical retrace occurs again, when it returns to its original state. The signal from the flip-flop is sent to all of the station boards where the Special Effect memory on each board determines whether the signal will be used to create a split image for this station.

KEYBOARD LOGIC

As can be seen from the above discussion, each depression of a control console button causes a number of functions to occur. These functions are generated in the

correct sequence, and, in some cases, are even remembered by the control console logic. This control logic is located near the keyboard (for convenience) and is constructed by a technique of interconnecting integrated circuits that is easily modified or expanded. This was essential, because many of the logic steps could not be completely identified until we had had an opportunity to experiment with them.

The control unit communicates with the other elements of the system via the set of data and control buses that are wired in common to the various video and audio boards. In addition to receiving the signals that correspond to each push of a control button, the control unit has to determine correctly the state of the system from the data output buses and the memory in the control unit, and then apply power to the appropriate lights under the control buttons.

MAINTENANCE CONSIDERATIONS

During the design of the second ICTS, we paid considerable attention to how to maintain the system after installation.²

There are 12 printed circuit boards in the new ICTS. Eight of these are essentially identical and four are each significantly different. We built an extra board, which is the same as the eight identical boards, to be used as a replacement if needed. The new ICTS was installed in November 1975, and the only failure we have experienced in the internal circuitry during regular classroom operation has been in one of the eight boards used for video switching. When our repair technician could not find the cause of the failure, he simply replaced the board with the spare. This replacement could also have been accomplished by the teacher, without the help of our technician.

We provided the teachers at Killian School with a *Self-Help Manual*, which consists of a list of problems that might occur and simple steps to resolve them. A section of the manual is included in App. C.

Our experience with the first ICTS taught us that students are prone to play with knobs or idly flip switches on the monitors or cameras. In many cases, student misuse was the cause of apparent malfunctions. Use of the *Self-Help Manual* has allowed teachers both to correct problems of this nature and to better describe situations to Rand personnel. Many such problems we have been able to resolve over the phone.

² We did not know, at the time of design, where the new system would be located. Fortunately, the ultimate site, Killian School, is only 40 miles from Rand, allowing us to cope with most maintenance problems ourselves.

REFERENCES

1. Genensky, S. M., H. E. Petersen, R. I. Yoshimura, J. B. von der Lieth, R. W. Clewett, and H. L. Moshin, *Interactive Classroom TV System for the Handicapped*, The Rand Corporation, R-1537-HEW, June 1974.
2. Clewett, R. W., S. M. Genensky, and H. E. Petersen, *An X-Y Platform for RANSIGHT-Type Instruments*, The Rand Corporation, R-831-HEW/RC, August 1971.
3. Genensky, S. M., H. E. Petersen, R. W. Clewett, and H. L. Moshin, *A Double X-Y Platform for RANSIGHT-Type Instruments*, The Rand Corporation, R-1614-HEW, December 1974.

Appendix A

MASTER CONTROL UNIT FOR THE NEW ICTS

FUNCTIONAL CAPABILITIES

The new master control unit (NMCU) has benefited from our experience with the earlier unit in use in Santa Monica's Madison Elementary School. Although more powerful, in many ways the NMCU is simpler, and thus easier to use. In what follows we describe the NMCU and explain in detail how to use it.

Figure A.1 is a schematic diagram of the NMCU. The two rows of buttons labeled ALL, SELF, and MANUAL make up the Mode portion of the NMCU. The depression of these buttons determines whether one station or all eight stations will be affected by the subsequent depression of buttons in the Display Control and the Special Effect, described below. Until otherwise specified, we shall assume that the buttons labeled MANUAL have been depressed and are illuminated. This assumption is equivalent to making the decision to restrict the control of video, via the NMCU, to one station at a time. The rows of buttons to the right of the Mode, starting with the ones labeled 1 and ending with the ones labeled VTR, are given the collective name Display Control. They, as well as the Special Effect buttons labeled SPLIT and OVERLAY, control the image displayed on each of the station monitors. There are eight station monitors—one at each of the seven student stations and one at the teacher's station.

The third row of buttons contains the Station Selector buttons. There are eight station selector buttons labeled 1 through 7 and T. When one of these buttons is depressed (and hence illuminated), it permits the user, by pushing the Display Control and the Special Effect buttons, to change the image displayed on the monitor at the station corresponding to the illuminated button in the array of Station Selector buttons. Thus, if we depress the 1 button in the array of Station

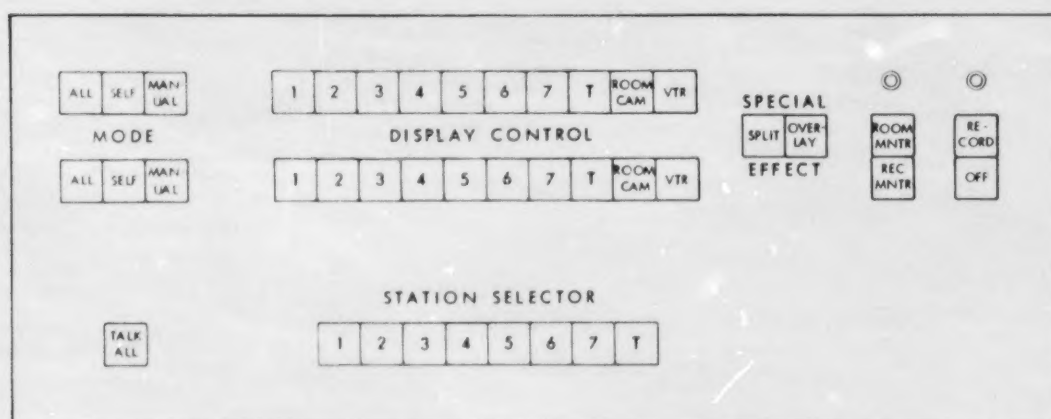


Fig. A.1—Schematic of the new master control unit (NMCU) control console

Selector buttons, we can use the buttons of the Display Control and the Special Effect to modify the image displayed on the monitor at station 1.¹ Generally, whenever any button of the NMCU is depressed, it is illuminated and remains so. (The value of these illuminated buttons will be explained later after we have described in detail what part each of them plays in controlling the visual and audio information available to each of the ICTS's monitors and stations.)

Another feature of the NMCU is that, when a Station Selector button is depressed, the content of the image being displayed on the station monitor associated with this button is also displayed on the teacher's monitor. For example, if the 4 button in the Station Selector is depressed, the content of the image being displayed on the monitor at station 4 is also displayed on the teacher's monitor. (However, as is explained near the end of this appendix, the contrast and the brightness of the images being displayed on these two monitors may differ markedly from one another if their contrast and brightness knobs are not properly adjusted.)

SPECIAL EFFECT AND DISPLAY CONTROL

Let us investigate how we compose the image displayed on a station monitor. We must understand the function of each of the buttons in the Display Control, as well as the Special Effect buttons that are labeled SPLIT and OVERLAY.

The SPLIT button, when depressed, permits the user, by pushing the buttons in the Display Control, to compose a horizontally split image on a station monitor. The upper half of the split image comes from any one of the ICTS's nine cameras or its videotape recorder, and the lower half comes from another one of these ten sources or from the same source.

The OVERLAY button, when depressed, permits the user, by pushing the buttons in the Display Control, to compose a whole-screen superposition of two images. One of the superimposed images comes from any one of the ICTS's nine cameras or its videotape recorder, and the other from another of these ten sources or from the same one.

The buttons in the first (or top) row of the Display Control, starting with one labeled 1 and ending with the one labeled VTR, can be viewed from two perspectives depending on whether the SPLIT or the OVERLAY button is depressed.

If the SPLIT button is depressed, depressing the button labeled 1 (in the first row of the Display Control) can be regarded as causing the upper half of the image on the monitor at the station, which corresponds to the illuminated button in the Station Selector, to consist of the upper half of the image being transmitted by the camera at station 1. If, for example, the button labeled T in the Station Selector is illuminated, this would mean that the upper half of the image seen on the teacher's monitor would come from the camera at station 1 and would consist of the upper half of the image being sent out by that camera.²

¹ This statement is valid when the "1s" in the sentence are replaced, respectively, by "2s," "3s," "4s," "5s," "6s," or "7s." It also remains valid when we replace "1" and "station 1," respectively, by "T" and "the teacher's station."

² The last two sentences are valid when the "1s" are replaced, respectively, by "2s," "3s," "4s," "5s," "6s," or "7s"; they also remain valid if "1" and "station 1" are replaced, respectively, by "T" and "the teacher's station." Similarly, the statements are valid if "1" and "the camera at station 1" are replaced, respectively, by "ROOM CAM" and "the room-viewing camera." Also, the statements are valid if "1," "the camera at station 1," and "that camera" are replaced, respectively, by "VTR," "the videotape recorder," and "that recorder."

Assume again that the SPLIT button is depressed, but this time that the 1 button in the second row of the Display Control is also depressed (rather than the corresponding button in the first row of this control). Thus, the lower half of the image being transmitted by the camera at station 1 would appear as the lower half of the image on the monitor at the station corresponding to the illuminated button in the Station Selector. If, for example, the button labeled 3 in the Station Selector is illuminated, this would mean that the lower half of the image being displayed on the monitor at station 3 would be the lower half of the image being transmitted by the camera at station 1. A few examples may help to clarify these statements.

EXAMPLE 1: Depress the 3 button in the Station Selector and then the following buttons: (1) the SPLIT button, (2) the T button in the first row of the Display Control, and (3) the ROOM CAM button in the second row of the Display Control. This will produce a horizontally split image on the monitor at station 3 (see Fig. A.2). The upper half of this image will be the upper half of the image being transmitted by the camera at the teacher's station, and the lower half will be the lower half of the image being transmitted by the room-viewing camera.

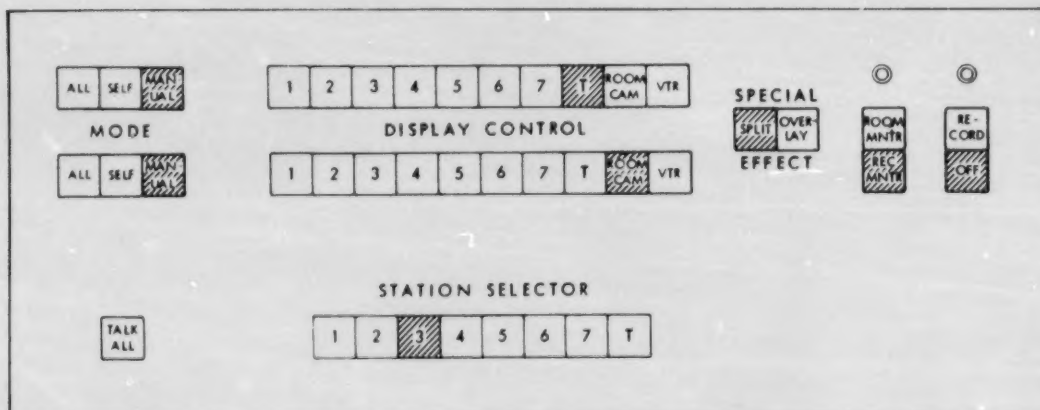


Fig. A.2 —NMCU control console indicating that station 3's monitor is displaying a horizontally split image; the top half is from the teacher's camera and the bottom half is from the room-viewing camera

EXAMPLE 2: Depress the 5 button in the Station Selector and then the following buttons: (1) the SPLIT button, (2) the ROOM CAM button in the first row of the Display Control, and (3) the 5 button in the second row of the Display Control. This will produce a horizontally split image on the monitor at station 5 (see Fig. A.3). The upper half of this image will be the upper half of the image being transmitted by the room-viewing camera, and the lower half will be the lower half of the image transmitted by the camera at station 5.

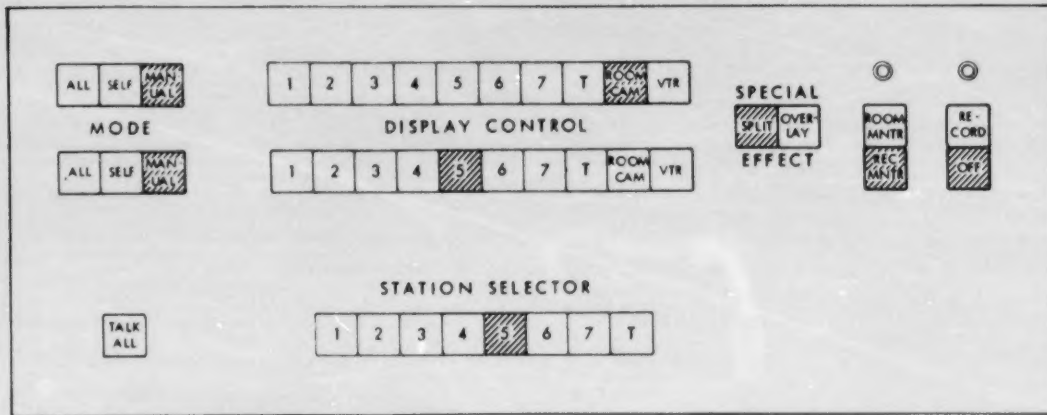


Fig. A.3—NMCU control console indicating that station 5's monitor is displaying a horizontally split image; the top half is from the room-viewing camera and the bottom half is from station 5's camera

EXAMPLE 3: Depress the 4 button in the Station Selector and then the following buttons: (1) the SPLIT button and (2) the 7 buttons in the first and second rows of the Display Control. This will produce on the monitor at station 4 a "full-screen" image of what the camera at station 7 is transmitting (see Fig. A.4).

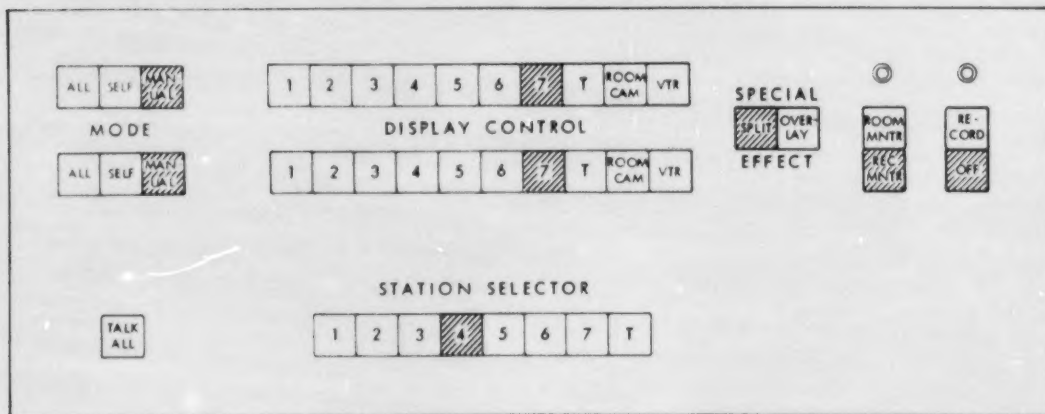


Fig. A.4—NMCU control console indicating that station 4's monitor is displaying a full-screen image of what station 7's camera is viewing

EXAMPLE 4: Depress the 2 button in the Station Selector and then the following buttons: (1) the SPLIT button and (2) the 2 button in the first and second rows of the Display Control. This will produce on the monitor at station 2 a full-screen image of what the camera at station 2 is transmitting (see Fig. A.5).

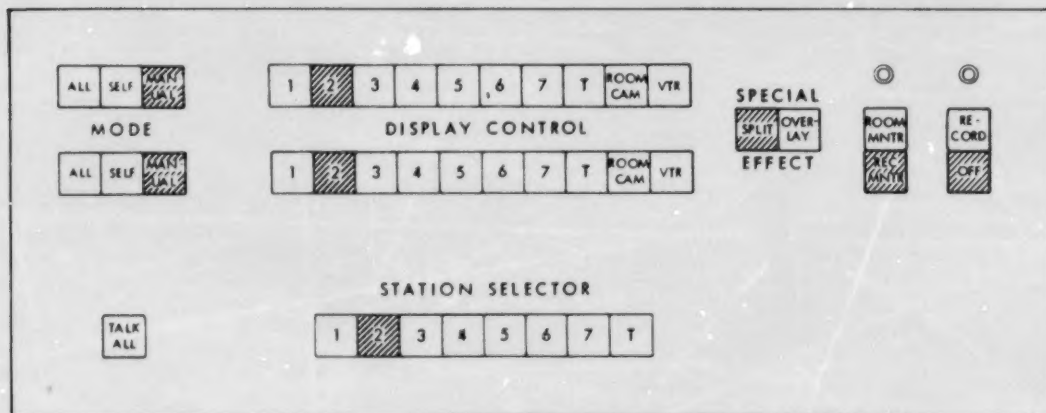


Fig. A.5—NMCU control console indicating that station 2's monitor is displaying a full-screen image of what the camera at this station is viewing

Assume that the OVERLAY button is depressed together with the 1 button in the first row of the Display Control. This will cause the "whole" image being transmitted by the camera at station 1 to appear as a full-screen image on the monitor at the station corresponding to the illuminated button in the Station Selector. However, superimposed on this image will be a full-screen image of what is being transmitted by the camera or by the videotape recorder associated with the depressed button in the second row of the Display Control.³ For example, if the 6 button in the Station Selector and the T button in the second row of the Display Control are illuminated, the image on the monitor at station 6 will be a superposition of a full-screen image of what the camera at station 1 is viewing and a full-screen image of what the teacher's camera is viewing.

Assume, again, that the OVERLAY button is depressed, but this time that the 1 button in the second row of the Display Control is also depressed (rather than the corresponding button in the first row of this control). In this case, the whole image transmitted by the camera at station 1 will appear as a full-screen image on the monitor at the station corresponding to the illuminated button in the Station Selector. However, superimposed upon that image will be a full-screen image of what is being transmitted by the camera or by the videotape recorder associated with the illuminated button in the first row of the Display Control. For example, if the T button in the Station Selector and the VTR button in the first row of the Display

³ The last three sentences are valid for the conditions outlined in footnote 2.

Control are illuminated, the monitor at the teacher's station will display a full-screen superposition of what is being transmitted by the camera at station 1 and by the videotape recorder.⁴

EXAMPLE 5: Depress the button labeled 3 in the Station Selector and then the following buttons: (1) the OVERLAY button, (2) the ROOM CAM button in the first row of the Display Control, and (3) the 3 button in the second row of the Display Control (see Fig. A.6). These produce on the monitor at station 3 a full-screen image that is the superposition of the image being transmitted by the camera at station 3 and the image being transmitted by the room-viewing camera.

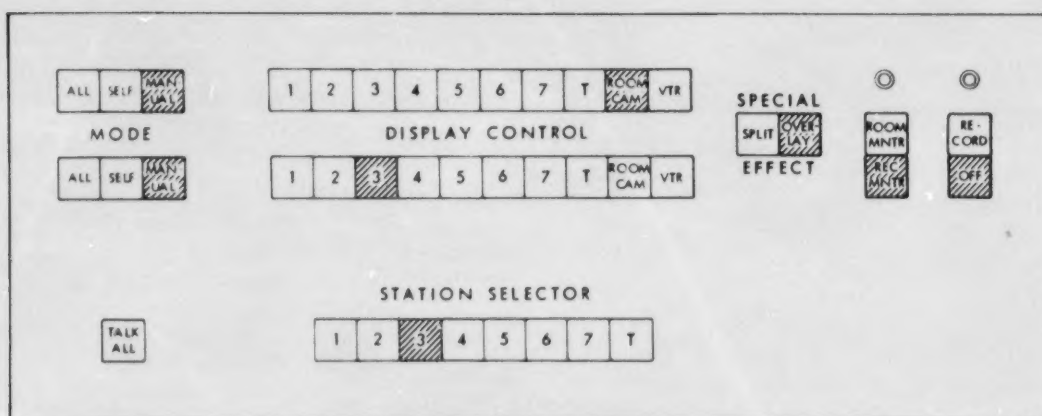


Fig. A.6—NMCU control console indicating that station 3's monitor is displaying a full-screen superposition of the output from the room-viewing camera on that from station 3's camera

EXAMPLE 6: Depress the button labeled OVERLAY and then the following buttons: (1) the button labeled 5 in the Station Selector and (2) the buttons labeled 5 in the first and second rows of the Display Control (see Fig. A.7). This produces on the monitor at station 5 a full-screen image that is the superposition of the image from the camera at station 5 upon itself. Here the signal being transmitted by the camera at station 5 is added to itself, so the resulting signal is twice as strong and the resulting image on the monitor is much brighter than it would have been if the SPLIT button had been depressed rather than the OVERLAY button. Depending on the brightness and contrast settings on the monitor, this use of OVERLAY can result in a better image or a distorted one.

We do not recommend that this type of overlay be employed unless the user needs to view an unusually bright, high contrast image in order to see it clearly or needs to view the image of very low contrast material. In general, we prefer that the following method be used to display on a station monitor a full-screen image

⁴ This paragraph is valid for the conditions outlined in footnote 2.

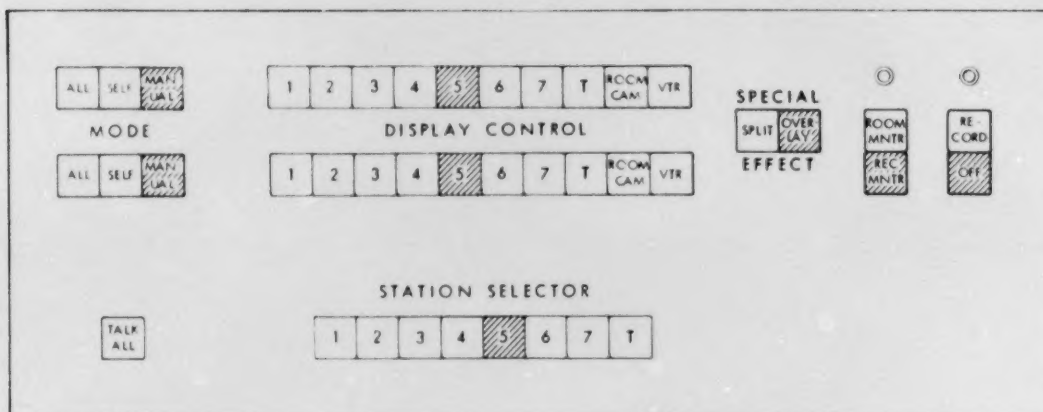


Fig. A.7—NMCU control console indicating that station 5's monitor is displaying a full-screen superposition of the output from the camera at this station on itself

of what is being transmitted by the camera at this station or by the camera at any other station. Depress the button corresponding to the desired station in the Station Selector, and then depress the SPLIT button along with the buttons in the first and second rows of the Display Control that bear the alphanumeric character of the station from which the video signal is to be received. For example, if we wish to display a full-screen image on the monitor at station 4 of what the camera at station 7 is viewing, we depress the 4 button in the Station Selector, then depress the SPLIT button and the buttons labeled 7 in the first and second rows of the Display Control (see Fig. A.4). The 7 button in the first row of the Display Control causes the upper half of the image being transmitted by the camera at station 7 to appear as the upper half of the image displayed on the monitor at station 4; similarly, the 7 button in the second row of the Display Control causes the lower half of the image being transmitted by the camera at station 7 to appear as the lower half of the image displayed on the monitor at station 4.⁵

THE ROOM MNTR BUTTON

Depressing the ROOM MNTR button (which is located to the right of the Special Effect buttons) causes the image on the station monitor associated with the illuminated button in the Station Selector also to appear on the room monitor/receiver.

EXAMPLE: If the 4 button in the Station Selector is illuminated and then the ROOM MNTR button is depressed, the image being displayed on the monitor at station 4 will also appear on the room monitor/receiver.

⁵ The remarks made in the last two paragraphs on the effect of using the OVERLAY or SPLIT buttons are also valid whenever an identically labeled pair of buttons in the Display Control are depressed, regardless of what button in the Station Selector is illuminated. (See example 4.)

The depression of the ROOM MNTR button will also turn on the reminder light above this button. This light will remain illuminated, regardless of what changes are made in the Station Selector, until the REC MNTR button, which is located directly below the ROOM MNTR button, is depressed. The reminder light above the ROOM MNTR button acts as a warning to the user that the image from one of the station monitors is being replicated on the room monitor/receiver. To determine which station is being monitored, the user need only press the buttons in the Station Selector, in some order, until the ROOM MNTR button is illuminated. The Station Selector button for which this occurs will correspond to the station monitor whose image is being replicated on the room monitor/receiver.

Suppose the room monitor/receiver was made to display what the monitor at station 6 is displaying and that, some time later, the Station Selector button 2 is illuminated. The reminder light above the ROOM MNTR button will be illuminated, but the ROOM MNTR button itself will not be illuminated. If the user has forgotten or otherwise does not know which monitor image the room monitor is replicating, he can find out by pressing the Station Selector buttons in some order, starting, say, at the button labeled 3. In this example, the ROOM MNTR button will light when the user depresses the 6 button, and he will then know that the image being replicated on the room monitor/receiver is the one being displayed on the monitor at station 6.

Now suppose that the ROOM MNTR button is depressed, and that the last time it had been depressed was when another button in the Station Selector was illuminated. Suppose further that the REC MNTR button was not depressed at any time between these two depressions of the ROOM MNTR button. Under these circumstances, the second depression of the ROOM MNTR button will cause the image displayed on the room monitor/receiver to change from a replication of the image displayed on the monitor at the station that corresponds to the Station Selector button that was illuminated the first time the ROOM MNTR button was depressed to a replication of the image displayed on the monitor at the station that corresponds to the Station Selector button that was illuminated the second time the ROOM MNTR button was depressed. Suppose that at a certain time the 7 button in the Station Selector is illuminated, and that, at that time, the ROOM MNTR button is depressed. At a later time (but before the time the REC MNTR button is depressed), the 2 button in the Station Selector is illuminated and while it is illuminated, the ROOM MNTR button is again depressed. This sequence of events will first cause the image displayed on the monitor at station 7 to be replicated on the room monitor/receiver, and to continue to be replicated on that monitor/receiver until the ROOM MNTR button is depressed a second time. At that time, the image replicated on the room monitor/receiver changes from that displayed on the monitor at station 7 to that displayed on the monitor at station 2.

THE RECORD BUTTON

Recording is accomplished as follows: Turn on the videotape recorder and set it to record, and then depress the RECORD button that is located to the right of the ROOM MNTR button. This causes the image on the station monitor associated with the illuminated button in the Station Selector to be recorded on the videotape recorder, together with the audio output from the station at which the monitor is located.

Suppose the 7 button in the Station Selector is illuminated, and the videotape recorder is turned on and set to record. If the RECORD button is depressed, the image on the monitor at station 7, together with the audio signal from this station, will be recorded on the videotape recorder.

The depression of the RECORD button will also turn on the reminder light above this button, and this light will remain illuminated regardless of what changes are made in the Station Selector. It can be turned off simply by depressing the OFF button, located below the RECORD button.

The reminder light above the RECORD button acts as a warning to the user that the audio and visual information from one of the ICTS stations may be being recorded on the videotape recorder. To determine which station this *might be*, the user need only press the buttons in the Station Selector until the RECORD button is illuminated. The Station Selector button for which this occurs will correspond to the station that *may be* transmitting video and audio signals to the videotape recorder.*

Suppose the videotape recorder was turned on and set to record and that the RECORD button was depressed when the 4 button on the Station Selector was illuminated. Some time later, the Station Selector button T is illuminated. Under these circumstances, the reminder light above the RECORD button would be illuminated, but the RECORD button would not be illuminated. If the user has forgotten or otherwise does not know which station's video and audio output are being recorded on the videotape recorder, he can find out by pressing the Station Selector buttons, starting, say, with the 1 button. In this example, the RECORD button will be illuminated when he presses the 4 button in the Station Selector; he will then know that the videotape recorder is recording the image being displayed on the monitor at station 4, as well as the audio signal from this station.

Now suppose that the videotape recorder has been turned on and set to record, and that, subsequently, the RECORD button is depressed. Suppose further since that time one or more depressions of buttons in the Station Selector (and possibly of buttons in the Display Control and the Special Effect) have occurred, but neither the RECORD button nor the OFF button below it have been manipulated. Now assume that the RECORD button is depressed a second time. This causes the video recorded by the videotape recorder to change from that displayed on the monitor at the station corresponding to the button in the Station Selector that was illuminated when the RECORD button was first depressed to that displayed on the monitor at the station corresponding to the button in the Station Selector that was illuminated when the RECORD button was depressed a second time. The second depression of the RECORD button also causes the tape recorder to stop recording audio from the first station and begin recording it from the second station. For example, at a certain time the T button in the Station Selector is illuminated, the videotape recorder is turned on and set to record, and the RECORD button is depressed. At a later time (one that occurs before the time that the OFF button below the RECORD button is depressed), the 1 button in the Station Selector is illuminated and the RECORD button is again depressed. This will result in the recording of the image displayed on the monitor at the teacher's station, as well as the sound from this station, until the RECORD button is depressed a second time. The videotape

* The words *might be* and *may be* were used because by merely observing the warning light above the RECORD button, we do not know whether the videotape recorder has been turned on and set to record. This information can only be gleaned by observing the videotape recorder itself.

recorder will then begin recording what is displayed on the monitor at station 1 along with the sound from this station.

When the RECORD button is depressed and a videotape recording is being made, it is not possible to activate either VTR button in the Display Control until the OFF button below the RECORD button has been depressed. Thus, the user cannot simultaneously record what is being displayed on a station monitor and view the resulting recording on another station monitor.

Besides recording from classroom sources, the videotape recorder used with the new ICTS can be tuned to the UHF and VHF TV channels displayed and heard on an ordinary TV receiver, and can record off the air. If the videotape recorder is tuned to an ordinary VHF or UHF TV station and the VTR buttons are depressed on the master control unit, the picture being received by the videotape recorder will be displayed on those station monitors for which VTR had been selected. The stations selected also receive the sound associated with the picture. Note that a recording is not being made from an ICTS station; hence, the RECORD button is not illuminated. However, because the videotape recorder used with the new ICTS is capable of recording TV programs off the air and because this capability is independent of its relation to the rest of the ICTS, it is not surprising to learn that the RECORD button is not used when the videotape recorder records material off the air.

THE ROOM MNTR AND REC MNTR BUTTONS

It is important to understand why the ROOM MNTR button and the REC MNTR button can, and probably should, be looked on as "the system monitor button" and "the videotape recorder monitor button," respectively. This is a consequence of the following features:

First, the depression of the ROOM MNTR button causes the image being displayed on the monitor at the station that corresponds to the illuminated button in the Station Selector to be replicated on the room monitor/receiver.

Second, the depression of the REC MNTR button, coupled with turning the room monitor/receiver to channel 6 and flipping the switch on the rear of the monitor/receiver from 300 to 75 ohms, permits the room monitor/receiver to display either prerecorded videotaped material or material that is being taped off the air or from the ICTS by the videotape recorder. Note that under these circumstances the REC MNTR button does not light up.

SOME REMARKS ON AUDIO

If the 1 button in the Station Selector is depressed or is already illuminated, the person at the teacher's station can use the ICTS's audio equipment at this station to speak to the student at station 1; likewise, the student at station 1 can use the ICTS's audio equipment at his station to speak to the person at the teacher's station.⁷ Note that the ICTS's audio equipment is located at each of the system's eight stations and that it permits two-way conversations between the teacher's

⁷ This sentence is valid for the first condition outlined in footnote 1.

station and each of the seven student stations. It does not, however, permit two or more student stations to use the audio equipment to speak to the teacher simultaneously. This is in contrast with the ICTS's *video* capability, which, as discussed above, does allow the teacher to be in two-way communication with one or more student stations at one time.

THE TALK ALL BUTTON

The TALK ALL button, when depressed, permits the user (the teacher or teaching assistant) to use the ICTS's audio equipment at the teacher's station to speak to all the system's seven student stations. Note that it does not permit the people at all the student stations to speak to the person at the teacher's station via a microphone-speaker communication link. Only the person located at the station corresponding to the illuminated button in the Station Selector has a return audio capability.

THE MODE BUTTONS

In the Mode section of the NMCU, which is located to the left of the Display Control, there are two ALL, two SELF, and two MANUAL buttons. These buttons can be used in either pure or mixed pairs. That is, the user can choose to depress both ALL buttons, both SELF buttons, both MANUAL buttons, the ALL button in the first row and the SELF button in the second row, the SELF button in the first row and the MANUAL button in the second row, etc.

The Manual-Manual Mode

This is the most flexible mode available with the NMCU, because it does not impose constraints on (1) the manipulation or reaction of the other buttons on the NMCU and (2) on the operation of the rest of the ICTS beyond those imposed by the basic logic of the system. Thus, when the Manual mode is entered, no changes occur in the status of any buttons on the NMCU (except, of course, those that may have occurred because one or both MANUAL buttons have illuminated and the light in one or two of the ALL or SELF buttons has gone out). Every distinguishable combination and permutation of image displays that are possible with the ICTS can be set up while the NMCU is in the Manual-Manual mode. The only reason other modes (namely, the All and Self modes) were incorporated into the ICTS was because experience had shown that certain important and frequently occurring station monitor displays could be summoned more rapidly and simply if the other modes were available. Here we are referring specifically to the All-All, All-Self, Self-All, and Self-Self modes. (The other four mixed modes were not urgently needed and are available because they are the logical consequence of a system that incorporates the other five modes.)

The All-All Mode

When both ALL buttons are depressed, all the lights in the Display Control and the Special Effect go out. This signifies to the user that he must choose what to

display simultaneously on all eight station monitors and which of the two Special Effect options to use. As these choices are made, the depressed buttons light up.

Suppose the user wishes to present, simultaneously on all eight station monitors, a superimposed, full-screen image of what the room-viewing camera is looking at and what the teacher's camera is viewing. This can be accomplished by depressing both ALL buttons, and then depressing the OVERLAY button, the ROOM CAM button in either row of the Display Control, and the T button in the other row of the Display Control. Figure A.8a shows a schematic of the NMCU before setting up this problem. It is assumed that the NMCU was in the Manual-Manual mode, the 6 button in the Station Selector was illuminated, and the monitor at station 6 was displaying a horizontally split image. The top half is from the camera at station 1 and the bottom half is from the teacher's camera. Figure A.8b shows the NMCU immediately after the two ALL buttons in the Mode selector were depressed. Figure A.8c shows the control unit when the decision was carried out to display on all station monitors a full-screen superposition of what the teacher's camera is viewing on what the room-viewing camera is looking at. In Fig. A.8c we could have chosen to show that the T button in the first row of the Display Control and the ROOM CAM button in the second row of this control had been depressed, and still have fulfilled the conditions of the problem.

The Self-Self Mode

When both SELF buttons are depressed, the light in the Special Effect goes out and the pair of buttons in the Display Control that have the same label as the illuminated button in the Station Selector are illuminated. This signifies to the user that he must choose which Special Effect option is to be used. As this choice is made, the selected Special Effect button is illuminated. The SELF buttons allow the user

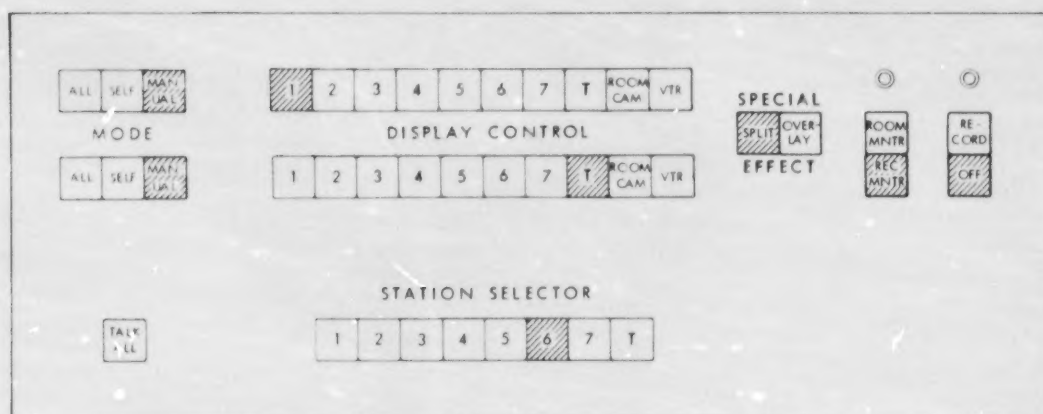


Fig. A.8a—NMCU control console indicating that station 6's monitor is displaying a horizontally split image; the top half is from station 1's camera and the bottom half is from the teacher's camera

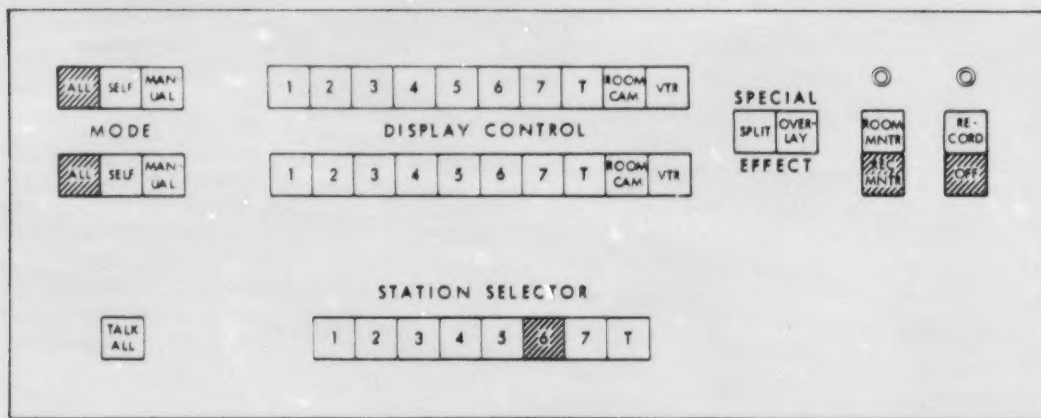


Fig. A.8b—NMCU control console indicating that the ICTS is in the All-All mode and that the choice of image composition has yet to be made

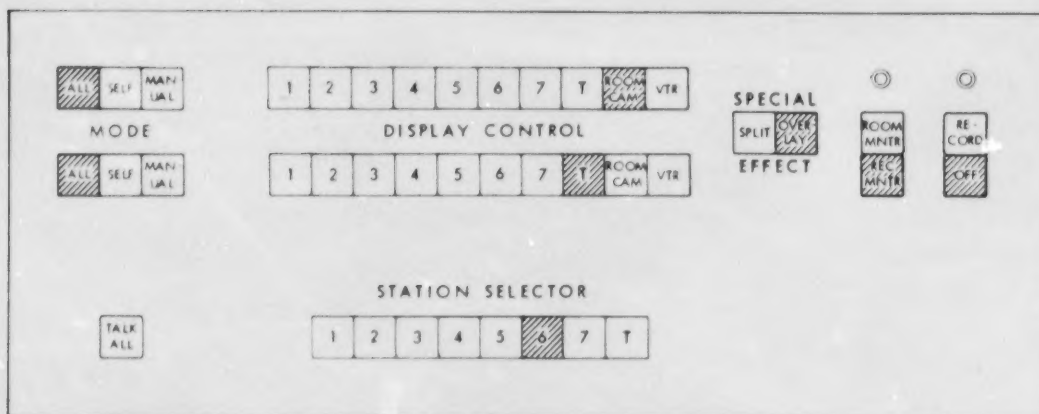


Fig. A.8c—NMCU control console indicating that every station monitor is displaying a full-screen image of the output from the room-viewing camera superimposed on that of the teacher's camera

to present on each station monitor all or part of what is being transmitted by the camera at its station. That is, each station monitor sees all or part of what the camera at its station is looking at.

Suppose the user wants the person at each of the ICTS's eight stations to view on his station monitor what is being transmitted by the camera at his own station; suppose further that he wants this done using the split image option. The user depresses both the SELF buttons, and then depresses the SPLIT button. Had the

user chosen the overlay or superposition option, he would have depressed the OVERLAY button; the resulting images on the station monitors would have been brighter, and may have had greater contrast.

The All-Self and Self-All Modes

When the ALL button in the first row of the Mode selector and the SELF button in the second row are depressed, the lights in the first row of the Display Control and in the Special Effect go out; and the button in the second row of the Display Control, which has the same label as the illuminated button in the Station Selector, is illuminated. This indicates to the user that he must choose what image to present on all eight station monitors, and how to combine this image with the image being transmitted by each station camera to its station monitor. As these decisions are put into effect by depressing a button in the first row of the Display Control and a button in the Special Effect, these buttons are illuminated.

Suppose that the user wishes to have the monitor at each station display the output from its own camera; further he wishes to superimpose on each of these images the image being transmitted by the room-viewing camera. To accomplish this, he depresses the ALL button in the first row and the SELF button in the second row of the Mode selector. This will turn out both the light in the first row of the Display Control and the light in the Special Effect and will illuminate the button in the second row of the Display Control that bears the same label as the illuminated button in the Station Selector. The user then depresses the ROOM CAM button in the first row of the Display Control and the OVERLAY button in the Special Effect.

If the user had depressed the SPLIT button rather than the OVERLAY button, this would have produced a horizontally split image on each of the eight station monitors. The upper half of the images on all of these monitors would have been the upper half of the image being transmitted by the room-viewing camera. The lower half of the image on each monitor would have been the lower half of the image being sent out by the camera at the same station as the monitor.

The depression of the SELF button in the first row of the Mode selector and the ALL button in the second row requires no new explanation. We can use the same explanation and example we used for the previous case, namely, the one in which the ALL button was depressed in the first row and the SELF button in the second row, if we merely make the following substitutions in that explanation: "second" for "first," "first" for "second," "lower" for "upper," and "upper" for "lower."

Observations Regarding the Pure and Mixed All and Self Modes

It is interesting to note that when one or both SELF buttons are illuminated, the buttons in the corresponding row or rows of the Display Control are disabled. For example, if the upper SELF button is depressed and the 5 button in the Station Selector is illuminated, the 5 button in the first row in the Display Control will be illuminated. Moreover, it is not possible to illuminate any other button in this row of the Display Control until a decision is made to leave the Self mode. This, of course, is reasonable, because otherwise it would be possible to violate the logic required by the Self operation.

It is also interesting to note that if the All-All, Self-All, All-Self, or Self-Self modes are chosen for use, the special effect that is subsequently chosen will prevail on all eight station monitors. While in any of these four modes, the special effect can be changed from Split to Overlay or from Overlay to Split, and the change will manifest itself on all eight station monitors. However, variations in the special effect among the stations can be made subsequent to the use of one or more of these four modes. This is accomplished by changing the mode to Manual-Manual, depressing the appropriate buttons in the Station Selector, and—while each of these Station Selector buttons is depressed—making the choice of special effect.

EXAMPLE 1: The user wants each station monitor to display a full-screen image of what the camera at its station is viewing; in addition, for all stations except 2 and 7, the user wants to use the Split special effect, while for stations 2 and 7, he wants to use the Overlay special effect. To accomplish these goals, the user can (1) depress both SELF buttons, (2) depress the SPLIT button, (3) depress both MANUAL buttons, (4) depress the 2 button in the Station Selector, (5) depress the OVERLAY button, (6) depress the 7 button in the Station Selector, and (7) depress the OVERLAY button. Figure A.9a shows the NMCU immediately after step (1), assuming that step (1) was carried out while the 3 button in the Station Selector was illuminated. Figure A.9b shows the control unit immediately before step (4). Figure A.9c shows the unit after step (4), and Fig. A.9d shows it after step (7).

EXAMPLE 2: Suppose the user wishes all station monitors except 3 and 6 to display a horizontally split image, the upper half of which comes from the room-viewing camera and the lower half of which comes from the camera at which the monitor is located. Further, the user wants the monitors at stations 3 and 6 to display a full-screen superposition of what the room-viewing camera is viewing on what the camera at each of these stations is looking at. To do this, the user can (1) depress the ALL button in the first row of the Mode control and the SELF button in the second row, (2) depress the ROOM CAM button in the first row of the Display Control, (3) depress the SPLIT button. (4) depress both MANUAL buttons in the

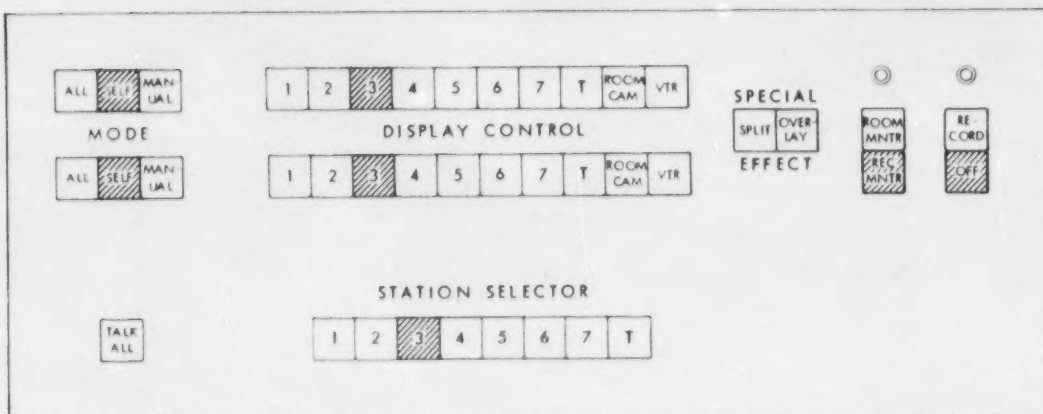


Fig. A.9a—NMCU control console indicating that the ICTS is in the Self-Self mode, but that the choice of special effect has not as yet been made

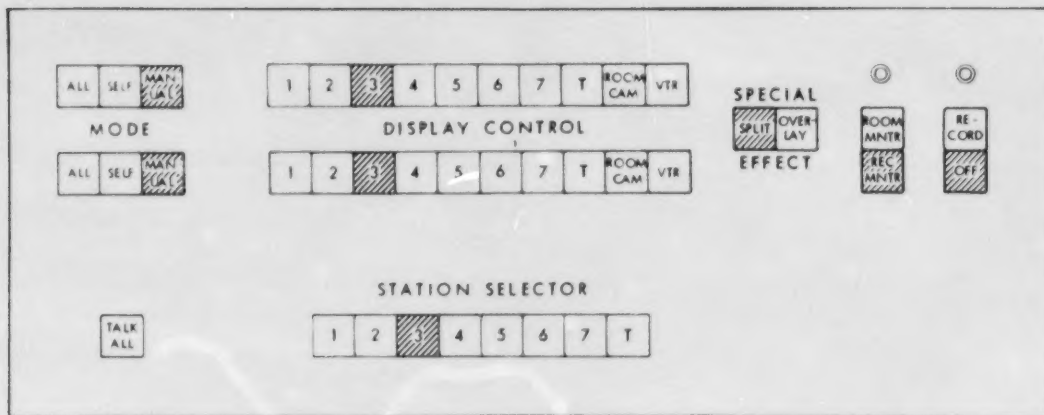


Fig. A.9b—NMCU control console indicating that station 3's monitor is displaying a full-screen image of the output from the camera at this station

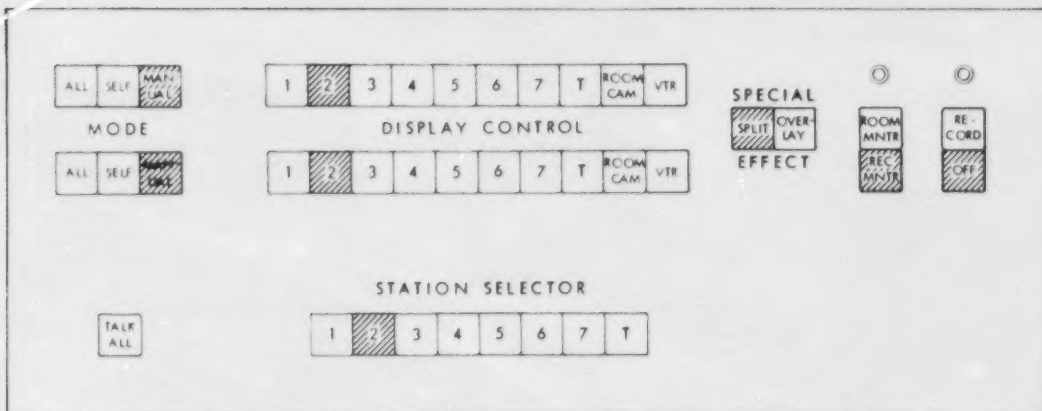


Fig. A.9c—NMCU control console indicating that station 2's monitor is displaying a full-screen image of the output from this station's camera

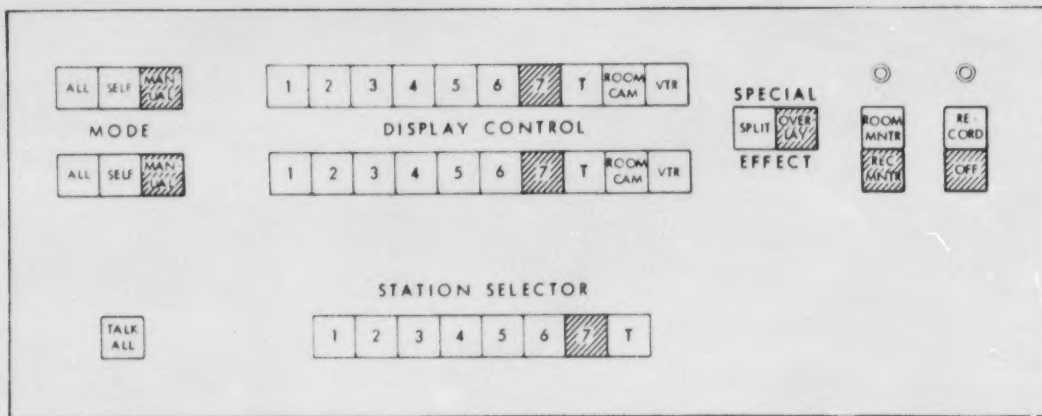


Fig. A.9d—NMCU control console indicating that station 7's monitor is displaying a full-screen image of the output from this station's camera superimposed on itself

Mode selector, (5) depress the 3 button in the Station Selector, (6) depress the OVERLAY button, (7) depress the 6 button in the Station Selector, and (8) depress the OVERLAY button. Figure A.10a shows the NMCU immediately after step (1), assuming the 4 button in the Station Selector was illuminated when step (1) was carried out. Figure A.10b shows the control unit after step (4), Fig. A.10c shows it after step (5), and Fig. A.10d shows it after step (8).

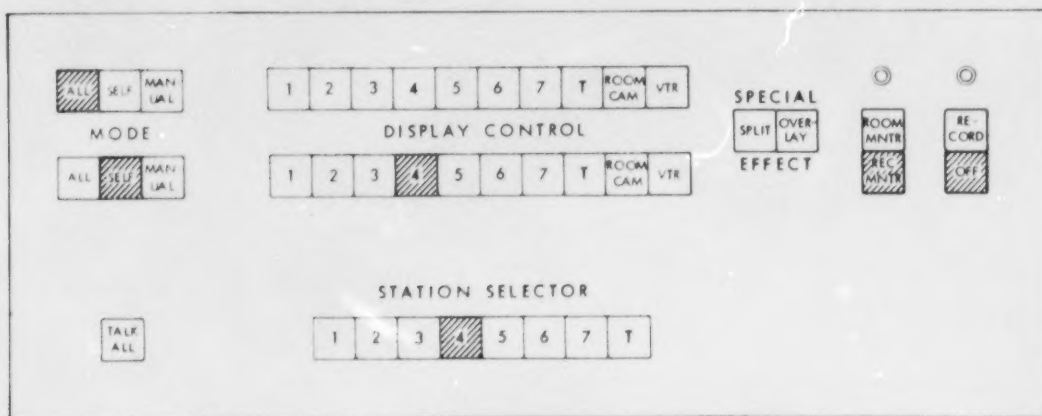


Fig. A.10a—NMCU control console indicating that the ICTS is in the All-Self mode, but that choices have yet to be made regarding the special effect and the image to be displayed on all station monitors

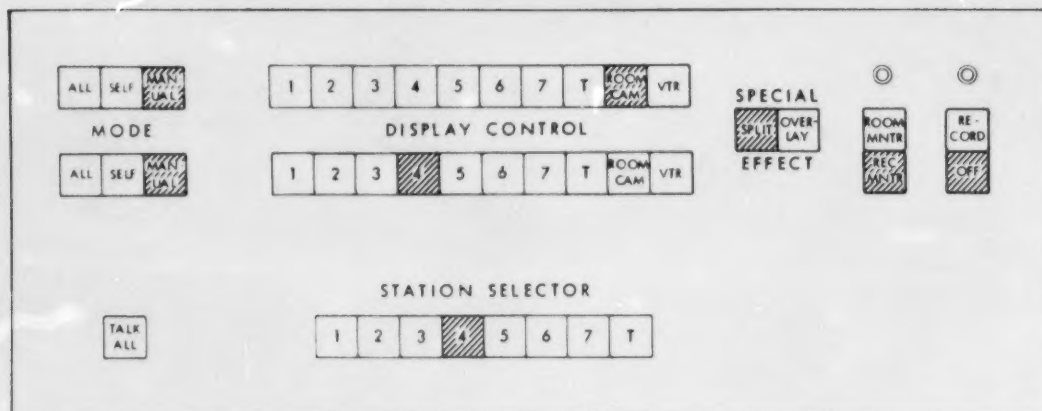


Fig. A.10b—NMCU control console indicating that station 4's monitor is displaying a split screen image; the upper half is from the room-viewing camera and the lower half is from station 4's camera

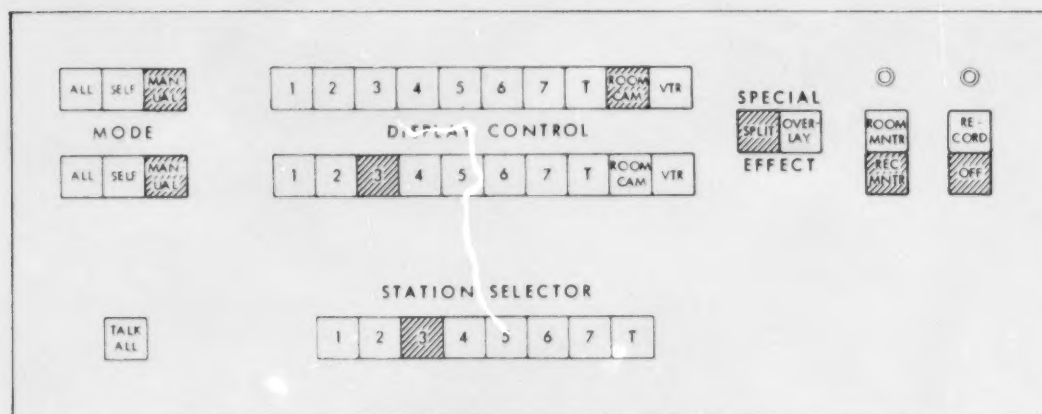


Fig. A.10c—NMCU control console indicating that station 3's monitor is displaying a horizontally split image; the upper half is from the room-viewing camera and the lower half is from station 3's camera

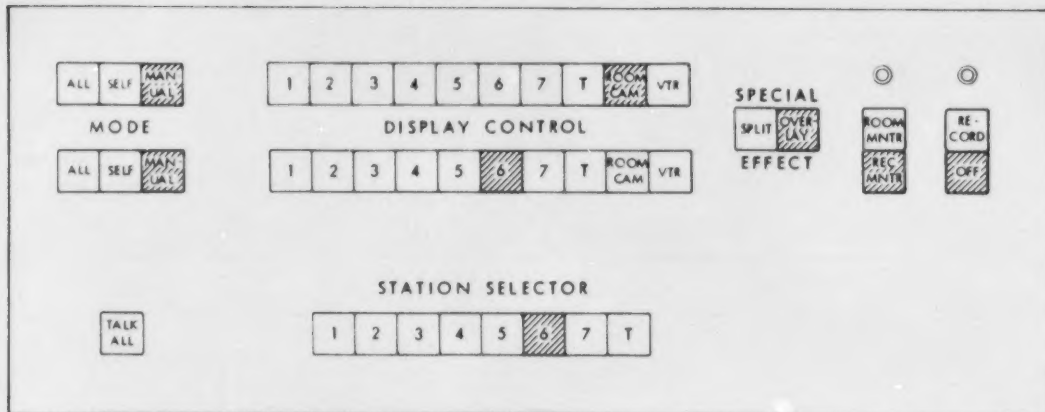


Fig. A.10d—NMCU control console indicating that station 6's monitor is displaying an image of the output from the room-viewing camera superimposed on that from station 6's camera

Mixed Modes with Manual as One Component

The Mode selector also allows the user to choose four other mixed modes: (1) All in the first row and Manual in the second row, (2) Self in the first row and Manual in the second row, (3) Manual in the first row and All in the second row, and (4) Manual in the first row and Self in the second row. When any one of these modes is chosen, the subsequent depression of the SPLIT or OVERLAY buttons affects all eight station monitors. As in the case of the All-All, Self-All, All-Self, and Self-Self modes, to be able to select a special effect for one or more stations that is different from that assigned when the NMCU is in the All-Manual, Self-Manual, Manual-All, or Manual-Self modes, the NMCU first must be returned to the Manual-Manual mode.

On entering the All-Manual mode, that is, on depressing the ALL button in the first row of the Mode selector and the MANUAL button in the second row, the lights in the first row of the Display Control and in the Special Effect go out. The status of the lights in the second row of the Display Control remains as it was before entering the All-Manual mode. Thus, the user is alerted to the fact that he must choose the image component that is to be displayed on all eight station monitors as well as the special effect that is to prevail on these monitors.

EXAMPLE 1: Each station monitor is displaying a full-screen image of what its station camera is viewing and the user wants to superimpose on these images what the room-viewing camera is looking at. This can be accomplished by entering the All-Manual mode, and then depressing the ROOM CAM button in the first row of the Display Control and the OVERLAY button in the Special Effect.

The Manual-All mode is the symmetric counterpart of the All-Manual mode. It is explained and illustrated by the previous two paragraphs if in these paragraphs "All-Manual," "first," and "second" are replaced, respectively, by "Manual-All," "second," and "first."

On entering the Self-Manual mode, that is, on depressing the SELF button in the first row of the Mode selector and the MANUAL button in the second row, the light in the Special Effect goes out. Further, the button in the first row of the Display Control bearing the same label as the depressed button in the Station Selector is illuminated, and the status of the illumination of the buttons in the second row of the Display Control remains as it was before entering the Self-Manual mode. Thus, the user is alerted to the fact that he must choose the Special Effect that is to prevail at all stations.

EXAMPLE 2: Stations 1, 2, 5, and 7 are viewing a full-screen image of the output from the videotape recorder while stations 3, 4, 6, and T are viewing a full-screen image of what the room-viewing camera is looking at. What will be displayed on each of the ICTS's eight station monitors if the Self-Manual mode is entered and the OVERLAY button is then depressed? The monitors at stations 1, 2, 5, and 7 will each display a full-screen image of what the camera at their particular station is viewing superimposed on the output of the videotape recorder. The monitors at stations 3, 4, 6, and T will each display a full-screen image of what the camera at their particular station is viewing superimposed on the full-screen image of what the room-viewing camera is looking at.

Using the same example, suppose the user now depresses, in the following order, the 6 button in the Station Selector, the MANUAL button in the first row of the Mode selector, and the SPLIT button in the Special Effect. In this instance, the images on all station monitors except 6 remain the same; the image on the monitor at station 6 becomes a horizontally split image, the upper half of which is the upper half of the image being transmitted by the camera at station 6 and the lower half of which is the lower half of the image being transmitted by the room-viewing camera.

The Manual-Self mode is symmetric with the Self-Manual mode. It is explained and illustrated by the three previous paragraphs if in these paragraphs "Self-Manual," "first," "second," "upper," and "lower" are replaced, respectively, by "Manual-Self," "second," "first," "lower," and "upper."

Additional Observations Concerning Modes

We may now ask how the ROOM MNTR, REC MNTR, and RECORD buttons, their reminder lights, the OFF button below the RECORD button, and the TALK ALL button behave in modes other than the Manual-Manual mode. The answer is simple and comforting. These buttons behave as they do in the Manual-Manual mode. However, when the light above the RECORD (ROOM MNTR) button is on, care must be taken in going from one mode to another in order to avoid unintentionally changing the output to the videotape recorder (room monitor/receiver).

EXAMPLE: The image displayed on the monitor at station 2 is being recorded on the videotape recorder, and this monitor is displaying a full-screen image of what the student at this station is writing on a piece of paper. Suppose both ALL buttons are depressed, followed by the depression of the ROOM CAM buttons in the Display Control and the SPLIT button in the Special Effect. As we already know, this will cause the whole image being transmitted by the room-viewing camera to be displayed as a full-screen image on all eight station monitors, including the one at station 2. Hence, the videotape recorder will no longer record what the camera at station 2 is viewing, but rather will record the image being transmit-

ted by the room-viewing camera. Thus, if the teacher had wanted to continue recording what the student at station 2 was writing, he would have been disappointed.

It should be noted that in going from one mode to another, the only buttons in the Mode selector that need to be depressed are those that represent a distinct mode change. For example, in going from the All-All mode to the All-Manual mode, only the MANUAL button in the second row of the Mode selector need be depressed.

INITIAL STATE OF THE NMCU

When the power is turned on, the following buttons are illuminated: both SELF buttons, both T buttons in the Display Control, the T button in the Station Selector, and the SPLIT button in the Special Effect. As has been pointed out above, this means that initially the monitor at each station is displaying a full-screen image of what the camera at this station is looking at.

MONITORING THE DISPLAY STATUS OF THE ICTS

It is very easy to monitor the display status of the ICTS, or to determine what is being displayed on each of the system's nine monitors. If the Room Monitor and Record reminder lights are on, this technique will also reveal what station monitor image is being replicated on the room monitor, and what station monitor image may be being recorded on the videotape recorder. The technique consists of merely depressing, in order, the buttons in the Station Selector; noting what buttons are illuminated in the Mode, Display Control, and Special Effect, and what buttons and warning lights are illuminated that are associated with the room monitor/receiver and the videotape recorder; and then properly interpreting what the combination of lighted buttons and reminder lights signifies.

EXAMPLE: Suppose the user decides to survey the display status of the ICTS and finds that (1) both MANUAL buttons are illuminated, as well as the reminder light above the ROOM MNTR button and the OFF button below the RECORD button; (2) when the 1 button in the Station Selector is depressed, the ROOM CAM buttons in the Display Control and the SPLIT button are illuminated (see Fig. A.11a); (3) when the 2 button in the Station Selector is depressed, the T button in the first row of the Display Control, the 2 button in the second row of this control, and the OVERLAY button are illuminated (see Fig. A.11b); (4) when the 3 button in the Station Selector is depressed, the 3 buttons in the Display Control and the SPLIT button are illuminated (see Fig. A.11c); (5) when the 4 button in the Station Selector is depressed, the 4 button in the first row of the Display Control, the T button in the second row of this control, and the OVERLAY button are illuminated (see Fig. A.11d); (6) when the 5 button in the Station Selector is depressed, the VTR buttons in the Display Control and the SPLIT button are illuminated (see Fig. A.11e); (7) when the 6 button in the Station Selector is depressed, the 6 buttons in the Display Control, the SPLIT button, and the ROOM MNTR button are illuminated (see Fig. A.11f); (8) when the 7 button in the Station Selector is depressed, the 5 button in the first row of the Display Control, the 3 button in the second row of this control, and the SPLIT button are illuminated (see Fig. A.11g); and (9) when the

T button in the Station Selector is depressed, the 3 buttons in the Display Control and the SPLIT button are illuminated (see Fig. A.11h).

From these conditions, the user may conclude that (1) the NMCU is in the Manual-Manual mode, the image on one of the station monitors is being replicated on the room monitor/receiver, and nothing is being recorded from the ICTS by the

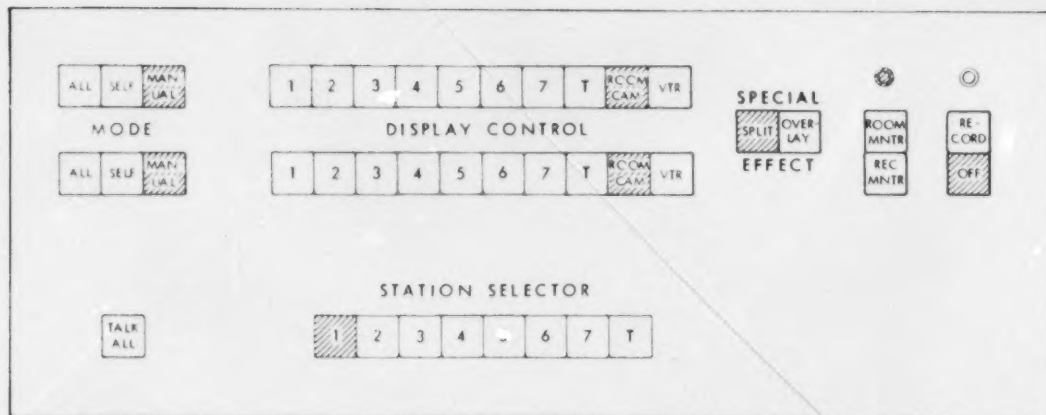


Fig. A.11a—NMCU control console indicating that station 1's monitor is displaying the output from the room-viewing camera

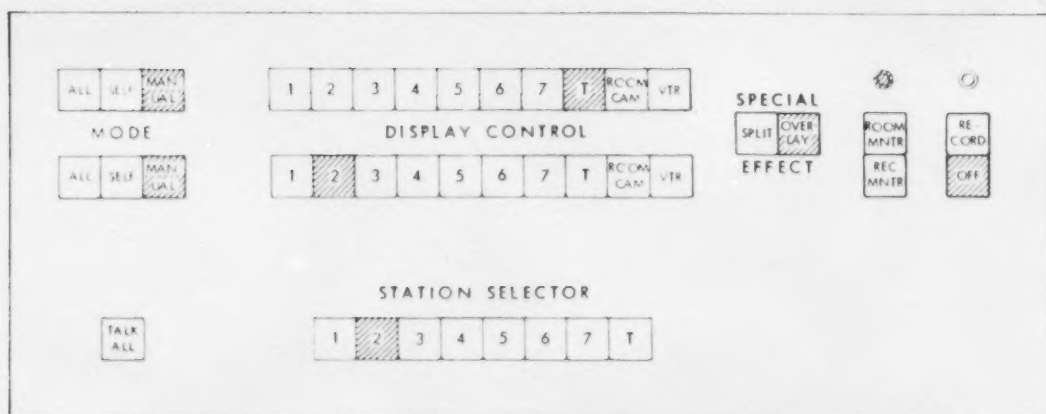


Fig. A.11b—NMCU control console indicating that station 2's monitor is displaying a full-screen image of the output from this station's camera superimposed on the output from the teacher's camera

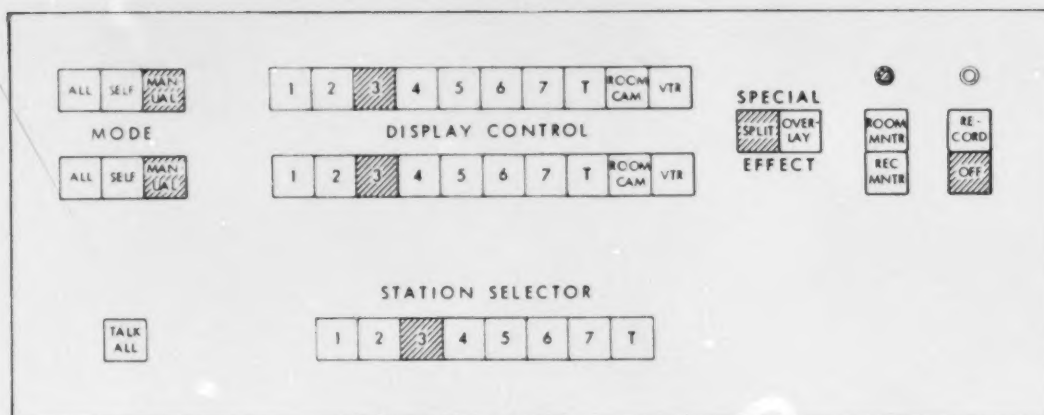


Fig. A.11c—NMCU control console indicating that station 3's monitor is displaying a full-screen image of the output from this station's camera

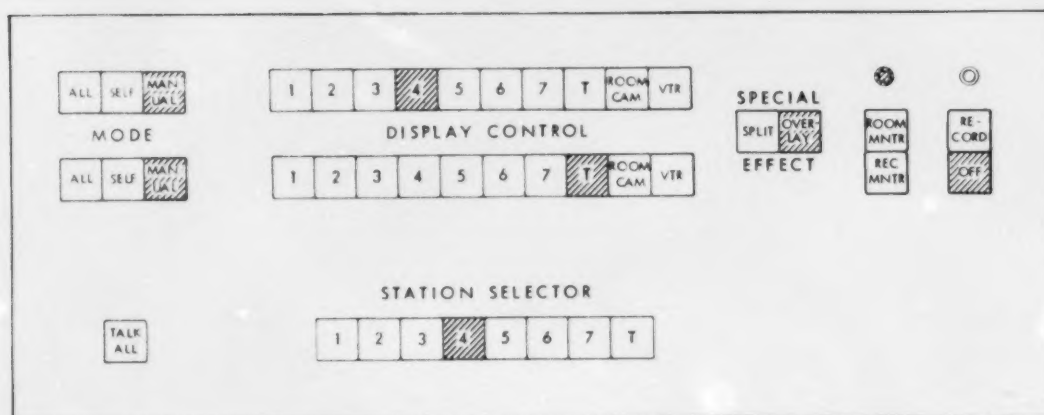


Fig. A.11d—NMCU control console indicating that station 4's monitor is displaying a full-screen image of the output from this station's camera superimposed on the output from the teacher's camera

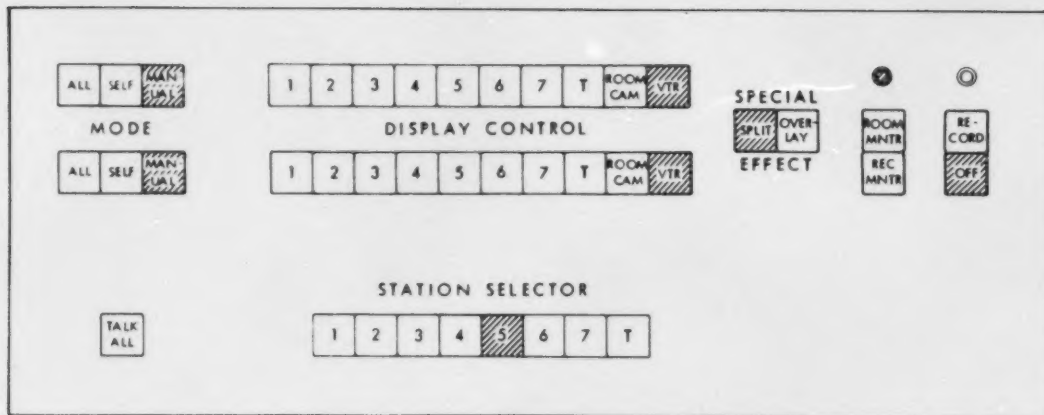


Fig. A.11e—NMCU control console indicating that station 5's monitor is displaying a full-screen image of the output from the videotape recorder

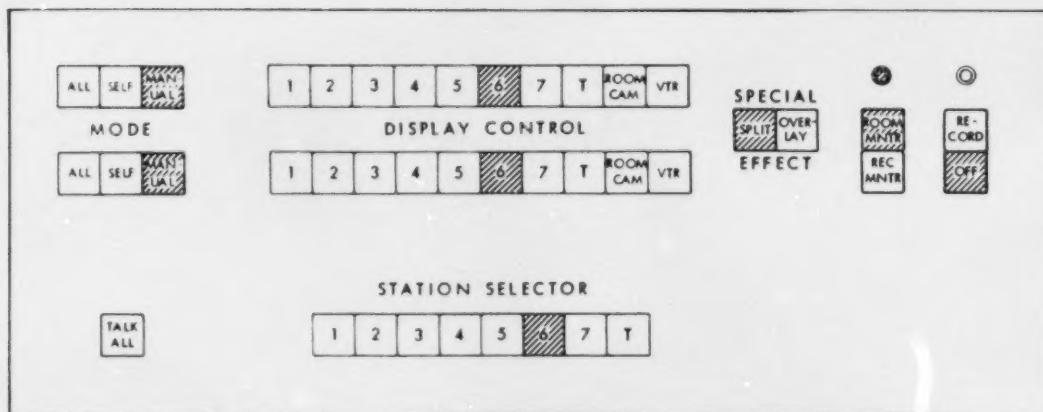


Fig. A.11f—NMCU control console indicating that station 6's monitor is displaying a full-screen image of the output from this station's camera and that this image is being replicated on the room monitor/receiver

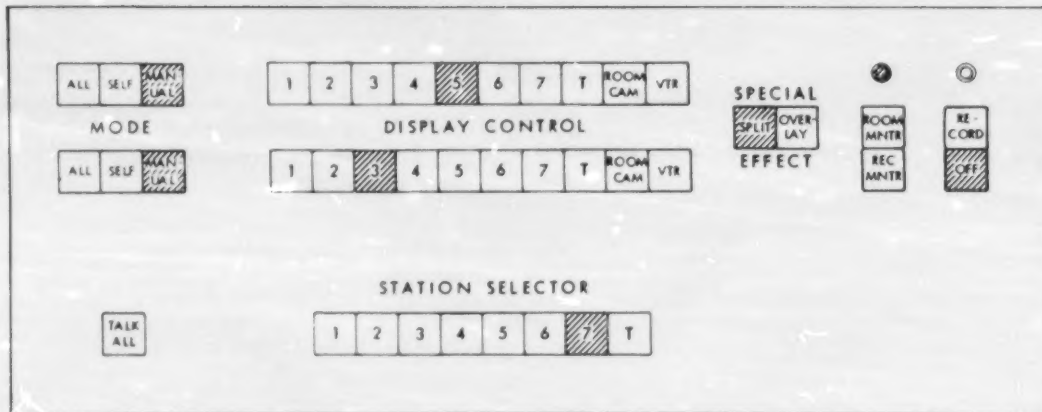


Fig. A.11g—NMCU control console indicating that station 7's monitor is displaying a horizontally split image; the upper half is the output from station 5's camera and the lower half is the output from station 3's camera

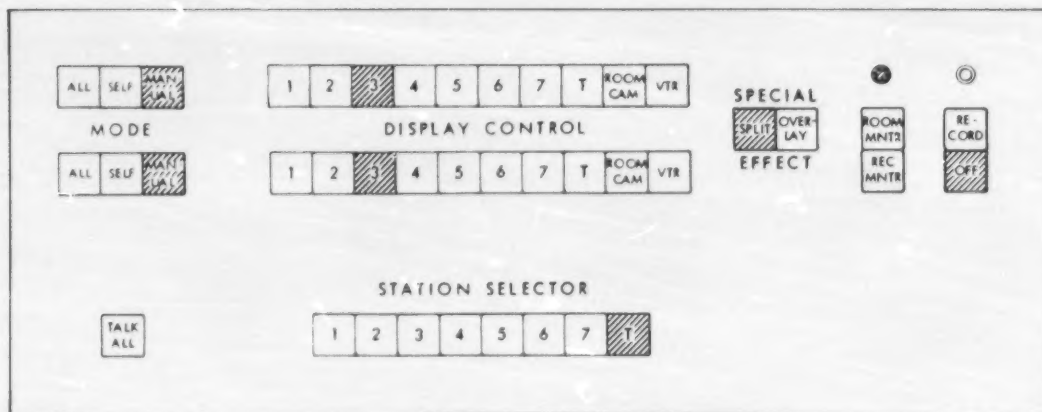


Fig. A.11h—NMCU control console indicating that the teacher's monitor is displaying a full-screen image of the output from station 3's camera

videotape recorder; (2) the monitor at station 1 is displaying a full-screen image of what is being transmitted by the room-viewing camera; (3) the monitor at station 2 is displaying a full-screen superposition of what is being transmitted by the camera at the teacher's station and by the camera at station 2; (4) the monitor at station 3 is displaying a full-screen image of what the camera at this station is viewing; (5) the monitor at station 4 is displaying a full-screen superposition of what the camera at station 4 is viewing and what the teacher's camera is looking at; (6) the monitor at station 5 is displaying a full-screen image of the output from the videotape recorder; (7) the monitor at station 6 is displaying a full-screen image of what the camera at this station is viewing, and, further, the image displayed on station 6's monitor is also being displayed on the room monitor/receiver; (8) the monitor at station 7 is displaying a split image, the upper half of which is the upper half of the image being transmitted by the camera at station 5, and the lower half of which is the lower half of the image being transmitted by the camera at station 3; and (9) the image displayed on the teacher's monitor is a replica of the image being displayed on the monitor at station 3.

Note that (9) is not "strictly true," because while the content of what is being displayed on the monitor at station 3 is also displayed on the teacher's monitor, the brightness and contrast of the images on these monitors may differ markedly from one another. This follows from the fact that the brightness and contrast of the image on each of the ICTS's nine monitors can be controlled at the monitor itself, and from the additional fact that the manipulation of the contrast and brightness knobs at one monitor in no way affects the brightness and contrast of the image on any other monitor. Also note that while changing from the automatic (All and Self) modes to the Manual mode during a survey does not alter the results of the survey (except for changing the mode that the system is in); changing from the Manual to the automatic modes could prove disastrous.

Appendix B

COPY OF J. L. SHEPHERD LETTER REPORTING ON X-RAY MEASUREMENTS

JL SHEPHERD *and Associates*

703 So. Pacific Avenue, Glendale, California 91204

213/245-0187

Irradiation Equipment

Counting Systems

Nuclear Applications

December 17, 1975

REPORT

Rand Corporation
1700 Main Street
Santa Monica, California

Attention: Samuel M. Genensky, Ph. D.
Physical Sciences Department

MEASUREMENT OF X-RAYS ASSOCIATED WITH TV MONITORS
AT KILLIAN SCHOOL, 19100 E. KILLIAN, ROLAND HEIGHTS, CA.

The equipment checked was as follows:

<u>Model</u>	<u>Serial</u>
Color Monitor Sony Trinitron KV - 1910	700103
Hitachi Hibaden Video Monitor VM-1720	170260
"	090014
"	170257
"	050120
"	170224
"	090050
"	090063
"	170212

Instrumentation:

The instrumentation used to measure the emergent radiation from the above listed units was a J. L. Shepherd and Associates USM-1A rate meter, complete with SP-12 GM probe with mica window with thickness of 1.4 mg/cm² and a window area of one square inch. The efficiency of the SP-12 probe is 2.5% as measured against a ⁵⁵Fe(5.9 Kev. photon energy) standard manufactured by Isotope Products Laboratories, with calibration traceable to National Bureau of Standards.

MANUFACTURERS

ENGINEERS

CONSULTANTS

Rand Corporation

-2-

December 17, 1975

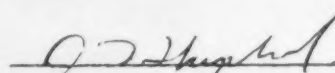
Measurements:

At no point on any monitor surveyed, as measured with USM-1A, did the count rate exceed 80 counts per minute above background.

82 counts per minute net (per square inch) - the area of the detector - and a detector efficiency of 2.5% represents a radiation field of .00038 mr/hr for 22.5 Kev X-Rays, the maximum voltage at which the monitor operates.

Conclusion:

We can conclude that the maximum radiation level as measured on the units was significantly less than 5% above normal background.


J. L. Shepherd

JLS/tl

Appendix C

MAINTENANCE INFORMATION FROM THE *SELF-HELP* MANUAL FOR THE NEW ICTS

In this appendix we describe what we anticipate to be the more common types of failures that might occur during the operation of the ICTS. Most failures are due to maladjustment in the positioning or setting of camera or monitor controls or switches. We have found that during a class students are prone to play with knobs or idly flip switches. Other failures, however, may be caused by a breakdown of a portion of the ICTS equipment.

We present below a description of each general problem and the procedures to follow, which are designed to be performed in the order presented. In many cases a problem will be resolved before all the suggested steps are carried out. If this does not happen, the final instruction is to place the malfunctioning station or stations in what we call the Local Self Mode.

LOCAL SELF MODE

The Local Self Mode allows limited operation of one or more stations that are unable to function with the remainder of the ICTS. The following procedure is used to activate this mode:

1. At the rear of the signal box at each station is a connector that accommodates a black cable that goes to a similar connector on the rear of the station's monitor. The end of the cable that is connected to the signal box should be disconnected and then reconnected to a similar connector on the top of the camera.
2. There is a two-position switch labeled V and VS on the back of the camera at each station. For normal ICTS operation, this switch should be in the V position, but for Local Self Mode it should be flipped into the VS position.
3. At this point, check the station monitor to see if the picture is stable. If it is, this station may be able to function as it would if the NMCU were permanently in the Self-Self mode for this station. Under these circumstances, the teacher may or may not be able to use the Station Selector to view on his monitor what is appearing on the screen of the monitor at the station on Local Self Mode.
4. If the picture on the monitor at the station is not stable, proceed as follows. On the top of the camera at each station, there is a small switch with two positions labeled INT and EXT. The normal position of this switch for ICTS operation is EXT. Flip the switch to INT and (if necessary to remove an unwanted pattern that may be appearing in the picture displayed on the monitor) disconnect the gray connector from the top of the camera.

This station has now been completely separated from the ICTS and will function only as a separate, independent CCTV system.

NOTE: When returning any station to normal operation from the Local Self Mode, make sure that all the switches, plugs, etc. are returned to their normal state as noted in the description above.

SOME POSSIBLE FAILURES

1. SLIGHTLY ROLLING OR TORN PICTURES WHEN SYSTEM IS FIRST TURNED ON AND/OR ROLLING OR TORN PICTURES WHEN SPLIT OR OVERLAY FROM TWO DIFFERENT CAMERAS IS USED; ALL OR NEARLY ALL STATIONS SHOWING THE SAME SYMPTOMS

- A. Turn control console power off for about 30 seconds and then turn it on again. Repeat several times if necessary to get the system into synchronism. This is known as the power off/on sequence. Make a note of this occurrence in the system logbook. Should this symptom occur frequently, please report it to Rand.
- B. Should the above procedure fail to correct the problem, put all stations in the Local Self Mode described above. Report the problem to Rand immediately, note it in the log, leave the system on, and check periodically to see if the power off/on sequence will correct the problem. This can be checked by the following procedure. Turn the room-viewing camera on, put one of the stations back on the system, and try a split between the station's camera and the room-viewing camera. Try the power off/on cycle again. If the system sync is right, the split should be normal. If the split is normal, reconnect the remaining cameras to the system.

Rand: There may be a sync generator failure, a 5-volt supply failure, or a blown fuse.

2. ROLLING OR TORN PICTURES ON ONE MONITOR; REST OF SYSTEM NORMAL

- A. Check horizontal and vertical hold adjustments of the monitor with the bad picture.
- B. Check the 75-ohm switch on the back of the monitor. It should be in the ON position. Flip it back and forth a few times and then to the ON position.
- C. Using the Display Control on the console, try several combinations of cameras and special effects. Note the results obtained and call Rand.
- D. Put the station into the Local Self Mode. Record the time of occurrence of the problem, the time lost by the teacher in trying to correct the problem, and the time lost by the student (if any).

Rand: There is probably a synchronization or blanking failure in the station board output stage.

3. NO PICTURE ON ONE STATION MONITOR WHEN ANY OF THE CAMERAS ARE BEING USED; REST OF SYSTEM NORMAL

- A. Is the station and monitor power turned on? Check the circuit breaker at the rear of the station power box. If necessary to reset it, turn the station power off and push in the small white button on the breaker to reset it.
- B. Readjust the brightness and contrast on the monitor.
- C. Check the 75-ohm switch on the back of the monitor. It should be in the ON position. Flip it back and forth a few times and then to the ON position.
- D. Be sure the black cable from the monitor to the station signal box is properly connected.
- E. Be sure the gray system cable is properly connected to the station signal box.
- F. Check the contrast and brightness adjustment again. At the very least, you should get an all-white picture when the brightness control is set to its maximum clockwise position. If you do not, the monitor has probably failed. Check the power switches again and make sure the small light next to the on/off switch on the monitor is on. If this procedure does not work, report the monitor failure to Rand. If the monitor is working, try the next step.
- G. Try the Local Self Mode for the monitor and then call Rand.

Rand: If F fails, a monitor failure has probably occurred. If G works, a cable or station board failure may be the problem.

4. NO PICTURE ON ANY OF THE STATION MONITORS, BUT CONSOLE LIGHTS NORMAL

- A. Check power to all stations; check if lens caps have been removed; check for disconnected cables; check that the 75-ohm switches on all monitors are on; check if all cameras are turned on, etc.
- B. Turn the main console power off for about 30 seconds. Turn it back on, and check the system again. If the lights in the console go on, find out if you can get normal keyboard light responses when changing the Station Selector and the Display Control even though no images are seen on any of the monitors. Proceed to step C or D.
- C. Turn power off at the back of the main console, and check the four fuses in the power supply chassis. (To do this, remove the back panel of the console as if you were going to read the elapsed time meters.) The four fuses to be checked are located in the chassis directly above the meters and are near the center of the power supply chassis. Replace any burned-out fuses with one of the same current rating. Replace the rear panel, turn the power on, and again check the system performance.
- D. If these steps fail, put all stations in Local Self Mode and call Rand. Turn off the power to the control console. You should still be able to work in the Local Self Mode.
- E. Be sure to make appropriate entries in the system log.

Rand: There has probably been a power supply failure in plus 8- or minus 12-volt power supplies. There could be an overvoltage or over current condition. Also check the zener diode used to supply minus 8 volts.

5. NO LIGHTS ON CONTROL CONSOLE; EVERYTHING ELSE NORMAL

- A. Turn the room-viewing camera on with the power switch on the room camera controller and listen for a click from within the main console. If no click is heard, check the fuse for the 6-volt power supply and if possible replace it. ***Be sure to turn the power to the console off before checking the fuses.***
- B. If the problem is not corrected, call Rand. Be sure to make an appropriate entry in the system log. You should be able to use the system in a normal way except that no lights will be available to indicate the status of the Display Control and the room-viewing camera.

Rand: Probably a failure of the 6-volt power supply or fuse has occurred.

6. LIGHTS ON CONTROL CONSOLE CHANGE WHEN NO CHANGE SHOULD OCCUR; IMAGES ON THE MONITORS MAY OR MAY NOT CHANGE AT THE SAME TIME; THIS MAY OCCUR ONLY WHEN ONE STATION IS SELECTED

- A. Open the rear panel and push each circuit board firmly into its socket.
- B. If this does not work, call Rand. Make an entry in the system log.

Rand: The problem is probably due to noise on the control buses.

7. NO PICTURE OR A ROLLING OR TORN PICTURE ON TEACHER'S MONITOR; EVERYTHING ELSE NORMAL

- A. Check that the 75-ohm switch on the back of the teacher's monitor is on. Check that the black cable is firmly connected to the connector on the rear of the monitor.
- B. Open the rear panel to the control console and check that the black signal cable is correctly and firmly connected to the connector, on the right side of the cable panel, labeled "teacher."
- C. Push the I/O board firmly into its socket. The I/O board is the ninth board from the left, is distinctly different from the others, and is next to the empty area.
- D. If all the above fail, disconnect the black cable from the connector inside the console and connect it to the connector on the back of the signal box on the teacher's camera stand. The teacher now must use the T Station Selector button to see what is going on in the system. That is, to see what student 1 is doing, the teacher must first choose station 1 on the Station Selector, determine how the Display Control and the Special Effect are set, depress Station Select button T, and set the Display Control and the Special Effect in the same way they are set for station 1.

Rand: There is probably a malfunction in the teacher station board or I/O board.

8. A ROLLING OR TORN IMAGE FROM ONE CAMERA

- A. Check the INT/EXT switch on the top of the camera. It should be in the EXT position. Flip it back and forth a few times.

- B. Check the cable with the gray connector that attaches to the top of the camera. Be sure it is firmly located in its socket.
- C. Be sure the V/VS switch on the back of the camera is in the V position.
- D. Be sure that the gray system cable to the station is firmly in its socket at the back of the camera stand.
- E. Turn the camera power off for about 30 seconds.
- F. If desired, put the station in Local Self Mode and then call Rand.

Rand: There is probably a break in the H or V drive cable to the camera.